Power Engineering

Combining POWER PLANT ENGINEERING and POWER GENERATION

FOR ALL POWER ENGINEERS • STEAM, ELECTRICITY AND ALL OTHER POWER ENGINEERING SERVICES

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The PRACTICAL ENGINEER and ELECTRICIAN

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JULY 1950

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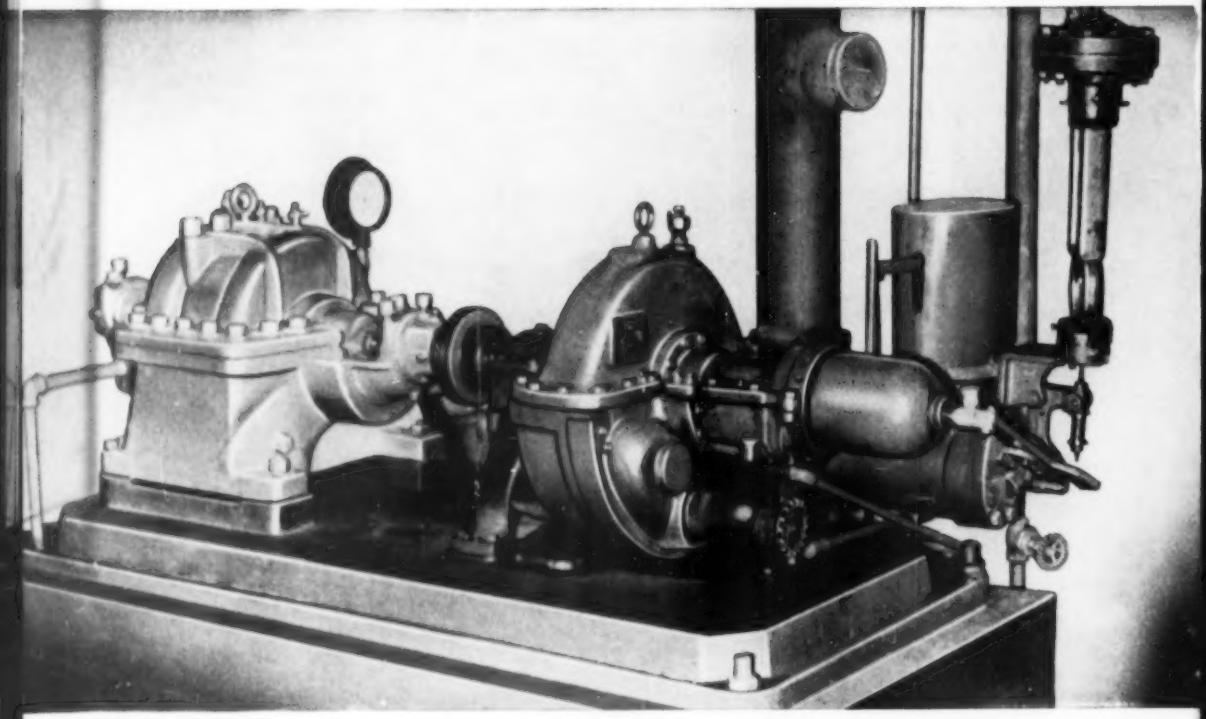

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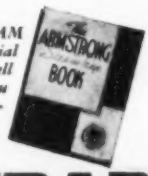

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Subscription Information—Published Monthly. Prices: United States and Possessions one year $10.00, Canada one year $11.00. Other countries one year $12.00. Single copies $1.00. The Annual Index is furnished as a part of the December issue.

Contents of back issues of Power Plant Engineering and Power Generation and Power Engineering will be found in both the Industrial Arts Index and the Engineering Index on file in Public Libraries.

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Power Engineering

Combining POWER PLANT ENGINEERING and POWER GENERATION

Established 1896 as Practical Engineer. Title changed to POWER PLANT ENGINEERING in 1918, to POWER GENERATION in 1948; and to POWER ENGINEERING in May, 1950. Rights reserved to above titles.

July 1950

VOLUME 54—NUMBER 7

Notes on This Issue

This month there isn't room on this page to say much about all the important and interesting items in this issue. The story on "Youngstown's New Boiler Unit" gives the kind of engineering detail which engineers want and without which a plant description is of no value. The editors are sure this story will rate highly with power engineers both in and out of the steel industry.

Construction of Short Circuit Current-Decrement Curves

To many people this would be a bewildering title, but to the electrical engineer it covers a very practical problem. He must have these curves to adjust relay settings. The graphical method described is simple to follow and involves practically no mathematics.

Diesels Augment Hydro Power

This is a short, well illustrated description of three new Diesel plants added by Bangor (Maine) Hydroelectric Company to its hydro-electric system to insure continuity of service under adverse water conditions. It will interest present and prospective operators of Diesels because of the detailed equipment list and the neat arrangement of the plants.

In the PRACTICAL ENGINEER Section

Oscar the Gas Works Owl gets involved with a Maharaja's false teeth and a condenser intake. Like Aesop's Fables, Oscar's escapades always point out a perfectly serious moral.

Maintenance of large storage batteries; insulation to prevent surface condensation; characteristics of fuel oils, and another article on Basic Power Plant Figuring are other items which we think you will like.

Charles Sanford Clarke

Charles Sanford Clarke, one of the founders of Technical Publishing Company and Secretary since 1908, died at his home in Wilmette, Illinois, on June 9, 1950.

To us who worked with him day-by-day and to his hundreds of friends in advertising and publishing, his passing brings a deep feeling of loss and at the same time gratitude for the privilege of knowing him.

"Charley" Clarke loved selling with every fibre of his being. His team-mates and his competitors agree that he was a truly great salesman with qualities of imagination, grit, determination, and intelligent application of accumulated knowledge all guided by a strict, uncompromising sense of fair play and honesty.

In our company councils Mr. Clarke has always been an unfailing source of courage and wisdom. Although he lived a long and useful life, he maintained an active interest in progressive publishing right to the end. Many times he has urged, "If we are sure it's right, let's get on with it."

Back at the turn of the Century, Mr. Clarke was a star salesman on the "Engineer." When that publication was sold in 1908, Clarke, Edward R. Shaw and Arthur L. Rice formed the Technical Publishing Company and bought the Practical Engineer (which is now POWER ENGINEERING).

Charley Clarke held the admiration, respect and love of all who knew him and will long live in our memories.

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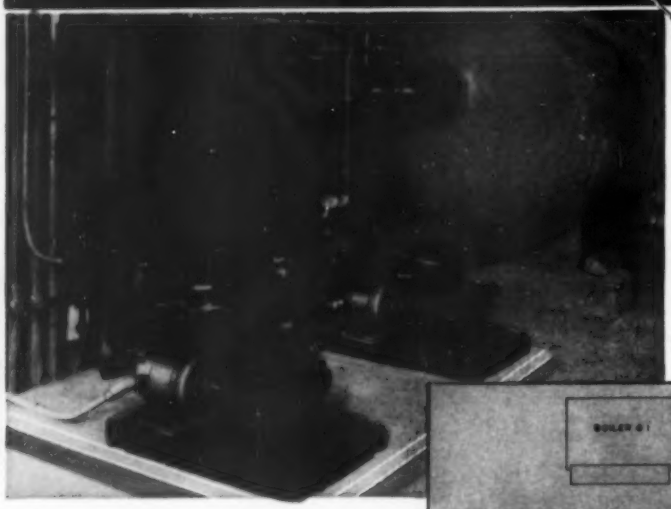

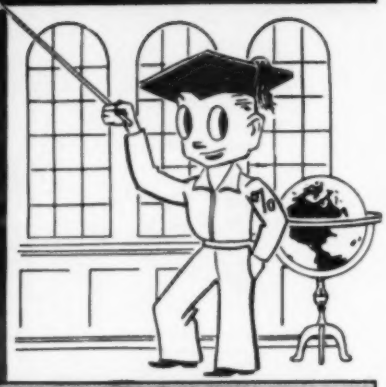

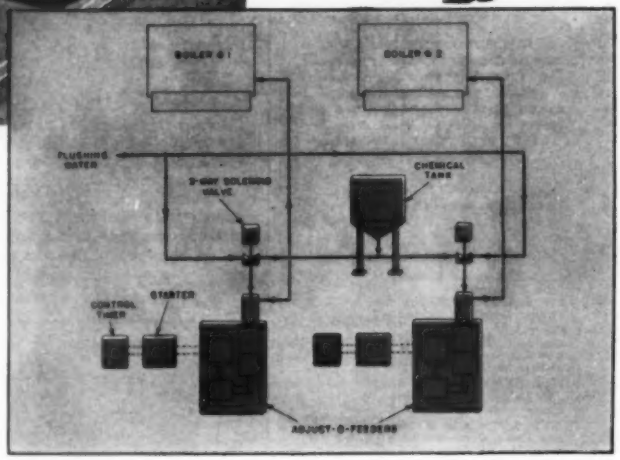

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ENGINEERS' PREVIEW

SOIL MICROBES—living organisms too small to be seen by the naked eye—exact a toll on natural and synthetic rubber insulated electric cables laid in soil, John T. Blake and Donald W. Kitchen of the Simplex Wire and Cable Co. reported at a recent meeting of the AIEE. It has been demonstrated that the loss of insulation resistance in active soil was due neither to water absorption nor to the action of soil chemicals but to attack by living micro-organisms. The engineers said that certain soil microbes consume natural rubber hydrocarbon, leaving visible surface pitting, but there were no visible signs of attack on synthetic rubber insulation. In both cases, however, action of the microbes caused low insulation resistance.

★ ★ ★

FOURTEEN young industrial executives, winners in a nation-wide competition, have been awarded Alfred P. Sloan Fellowships for Executive Development at the Massachusetts Institute of Technology. The fellowships provide an intensive one-year program of study in management policies and economic and social problems of industrial administration.

These men, who have been nominated by their employers as showing unusual promise for industrial leadership, will receive fellowships up to $3700. They will be on leave from their companies and upon completion of the program will return to the same companies.

In announcing the winners of the fellowships, Professor Gerald B. Tallman, Director of the Executive Development Program, said:

"This program provides an unusual opportunity for men of marked ability to study and evaluate business and economic problems with a mature viewpoint engendered by ten years of practical business experience."

★ ★ ★

ADEQUATE SUPPLY of iron ore in this country is primarily a production and cost problem. It is not a question of the exhaustion of the ore reserves in the United States. So said Benjamin F. Fairless president of United States Steel Corp., in the Celler committee hearings at Washington recently. The iron ore situation, he continued, is as follows:

"With the progressive depletion of the deposits of high-grade iron ore, it is gradually becoming more and more necessary to utilize lower-grade domestic ore deposits. United States Steel and others already have worked out methods for doing this and are far along with the plans necessary to accomplish this result.

"At the same time, United States Steel, as well as others, have thought it advisable to find and develop new sources of high-grade iron ore outside of the United States.

"Large foreign deposits of high-grade ore already have been found and are now under development. In other words, the American steel industry faces for the future a production and cost problem, and not one of scarcity of iron ore.

"Frankly, I cannot become too excited by the fact that certain people are only now discovering the problem which individual companies in the iron ore industry recognized years ago. How can I be, when the solution for the problem already has been found?"

ELECTRIC CONTACTS or "brushes," made of graphite and used to feed current to moving parts in motors or generators on high-altitude aircraft, may have their useful life increased many thousands of times as the result of new lubrication methods devised by Robert H. Savage, in the General Electric Research Laboratory.

His discovery about water, in the form of vapor, for the lubrication of graphite has changed accepted ideas that this solid and "slippery" material was a good lubricant in itself.

He has shown, however, that an invisibly thin film of moisture on graphite is required for its lubrication. Testing the wear against a revolving copper disk in a vacuum chamber, he found that dry graphite brushes were worn as fast as an inch an hour. When a small amount of water vapor was admitted to the chamber, the wear rate was reduced to less than a thousandth as much.

★ ★ ★

THE PROBLEM of pumping liquids under high vacuum was recently solved by an unusual pump having no mechanical connection between the power source and the pumping and valve mechanism. The pump operates electro-magnetically. The intake and exhaust valves are operated by the liquid being pumped, while the plunger is driven in one direction and returns by gravity.—*The Ohmite News.*

★ ★ ★

ZINC, in the past a weak metal of little use in engineering, now can be made as strong as brass, according to Dr. R. H. Harrington, of the G-E Research Laboratory. He has developed a new alloy composed principally of zinc, with small quantities of copper and beryllium added, which has approximately the same strength and electrical characteristics as brass. The alloy is said to be considerably cheaper than brass.

Called "zncube" (pronounced "zinc-cue-be"), from the chemical symbols for its makeup, the alloy has about eight times the useful strength of any zinc alloy now in use, Dr. Harrington said.

Among applications where cheaper zncube might be substituted for brass, Dr. Harrington lists lamp and fuse sockets and bases, panels, containers, mild springs, and many forms of hardware. The alloy is said to machine, solder, and resistance weld easily.

★ ★ ★

MANNED ONLY by an electronic "crew," a robot lightship—first ever built for ocean duty—will soon be helping to guide shipping into the nation's busiest port.

The U. S. Coast Guard announces that the 91-ft-long lightship "EXP-99" is nearing completion at Curtis Bay, Maryland. After a two-month dock trial at Curtis Bay, the lightship will be given further tests under actual service conditions near Scotland Lightship, one of three lightships marking the approaches to New York Harbor.

With the aid of a Visicode remote control system developed by the Westinghouse Electric Corp., a single operator at the Sandy Hook, New Jersey, Coast Guard Station will have complete control over the lightship's signaling system.

Technical Knowledge Is Not Enough

By JAMES D. CUNNINGHAM
President,
American Society of Mechanical Engineers

JAMES D. CUNNINGHAM

The accompanying article is abstracted from an address given by Mr. Cunningham following his receipt of the 1950 Merit Award of the Chicago Technical Societies Council. The citation for the award reads: "For Outstanding Achievement as an Engineer, Industrialist, Administrator, Civic Leader and Educator." The Award was presented at a meeting in Chicago, on May 9, 1950, by Dr. Gustav Egloff, of Universal Oil Products Company.

James D. Cunningham is president of ASME for 1950, president of Republic Flow Meters Co. and chairman of the board of trustees of Illinois Institute of Technology. He has held office as manager and regional vice-president of ASME and was made a Fellow of the Society in 1936. He has been very active for many years in educational, economic and civic organizations and, as a result, can speak with authority on a subject that must receive more and more attention from all engineers.

WE ARE the technical leaders of a great technical center in a nation that has won its way to world supremacy by technical mastery of its natural resources. The power over natural wealth and human destiny that is represented in this room would have been the envy of the kings and emperors of a few hundred years ago. Surely at this pinnacle of technical power in a mechanized civilization, we must be the happiest men and women the the world has ever seen!

The fact is, of course, that we are nothing of the kind. Instead of that, we are confused and apprehensive. Many of us look backward with longing to a time when we were much less powerful but much more serene, and wish we could turn the clock back to that simpler, happier day. Most of us look forward fearfully to a future that is dark with bewilderment, doubt and possibilities of catastrophe. The few of us who do see, or think we see, a way out of our present difficulties know in our hearts that there is little likelihood of our way out being followed. A calendar of special days and weeks issued by the U. S. Department of Commerce shows American Armed Forces Day coming right in the middle of National Pickle Week! This sums up our situation with a sort of desperate humor. It couldn't be said quicker!

As we contemplate the vast social and political complexity of the world today, it has become commonplace for us to say "Isn't it a tragedy—that we have concentrated our talents on technical problems to the neglect of human problems?" But for most of us this is just an expression, not a real belief.

We may brood about politics and public problems but we don't do anything about them. Mostly, we see them as a somber backdrop for our own individual triumphs of technique. We think if only everybody else were as brilliant and energetic as we are, the problems would be solved.

But eventually we come to the questions that many of us keep asking ourselves more and more frequently these days. Is technical progress enough? Does it justify our activity? If not, what are the other ends or objectives we should seek?

Of course, these are not new questions. Since the beginning of our civilization men have asked themselves these very same questions. The French philosopher, Rousseau, for example, put the question in a different and challenging form. He asked: Has the progress of science done man any real good? Obviously, we think the answer is "Yes!" and yet it may be worth while for us to examine the answer that Rousseau himself came to. He was skeptical. In Rousseau's judgment, the moral effects of science may have been so bad as to offset its physical advantages.

These are harsh words, and I doubt that many of us would acknowledge that they are true. But certainly it is a fact that skillful men are likely to become self-centered, and certainly this fact has something to do with the political and social difficulties in which we find ourselves today.

But there is another, and more important, respect in which our technical and moral interests are in conflict. I think it is fair to say that a large part of the technical mastery that we have achieved in this country has been the direct result of competition. Our customs and laws recognize the value of competition and seek to preserve it. Yet the emphasis on competition in our economic lives is in some conflict with the moral rules by which our personal lives are governed.

Is this the inevitable scourge of our efforts to conquer our environment, as Rousseau believed? Or is it rather the result of a competitive, technical interest that has become so intense that we have lost sight of other values? And can we now, by educating ourselves and our children, achieve the kind of balance of technical and spiritual forces that is essential to our happiness, if not to our survival?

I think it is encouraging that we have recognized the need and are making the effort. Our engineering and technical college faculties are awakening more and more to the need for humanizing the technical curriculum, and, what may be more significant, students themselves, in contrast to the attitude of just a few years ago, are welcoming and even demanding courses outside their chosen technical fields.

The reasoning behind these changes reflects the changing emphasis in our technical society—the awakening realization that technical know-how is not enough. As specialists many of you may resent the implication here that you have been less than you might have been as citizens and human beings. Look what you have contributed to human comfort and well-being through your technical accomplishments! Look at the number of people you employ, and the taxes you pay, and the civic contributions you make! What is expected of a citizen and a human being that you haven't given? You may well ask, and it is a fair question.

If science has simply made man more comfortable, if it has made him stronger and sleeker, and even healthier, it has not improved him intrinsically at all, and we have done all that could be expected of us as human beings. But if science has released man from the demands of animal existence so that he may turn his energies toward moral and spiritual improvement, then the possibilities are as great as the accomplishments to date are small, and many of us have failed in our chief responsibility as citizens and human beings.

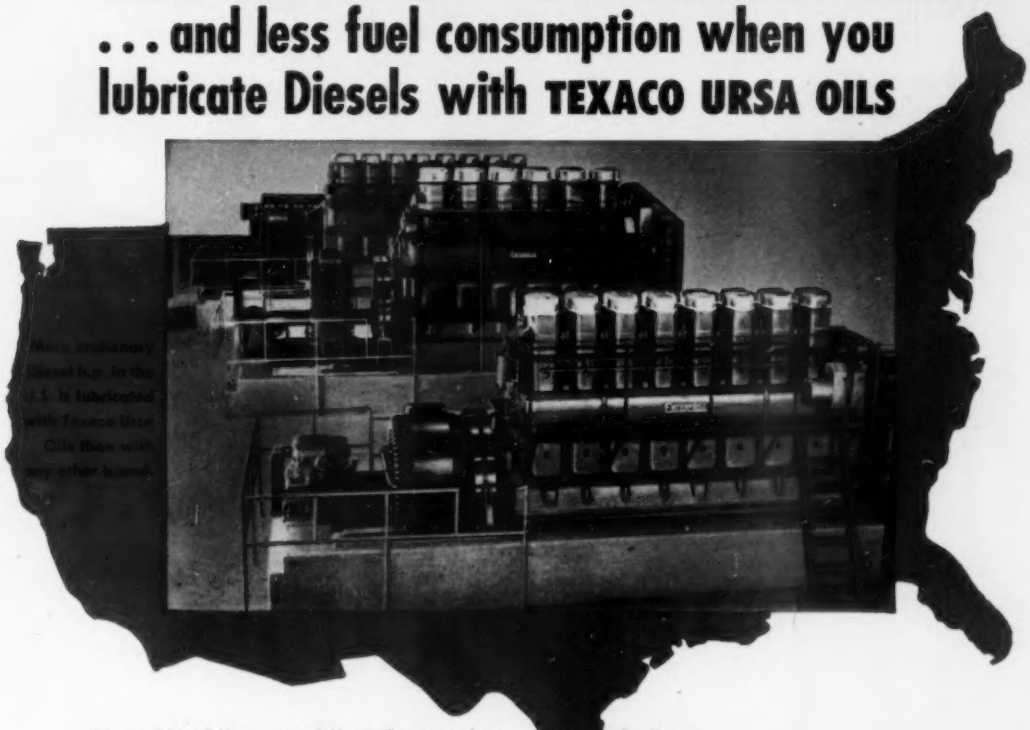
Is this just so much Sunday School talk, without any real meaning in a world of H-bombs, public debts and ward committeemen?

I don't believe it is. In fact, I

(Continued on page 116)

Better Compression ...Better Combustion

...and less fuel consumption when you lubricate Diesels with TEXACO URSA OILS



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For the full story on Yarway Indicators, write for a free copy of Yarway Bulletin WG-1822.

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YARWAY REMOTE LIQUID LEVEL INDICATOR, operated directly by the boiler water itself, by the pressure differential between a constant head and the varying head in the boiler drum. Indicating mechanism is never under pressure—no moving boxes. See Bulletin WG-1822.

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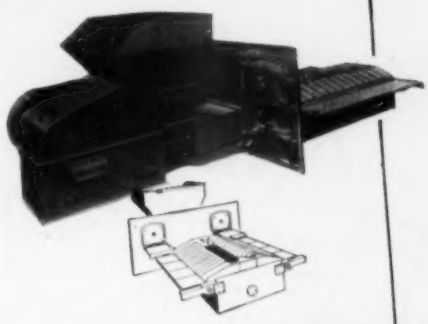
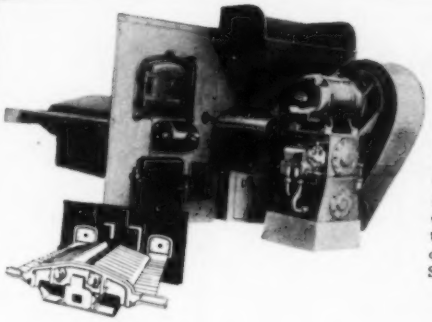




TYPE E STOKER

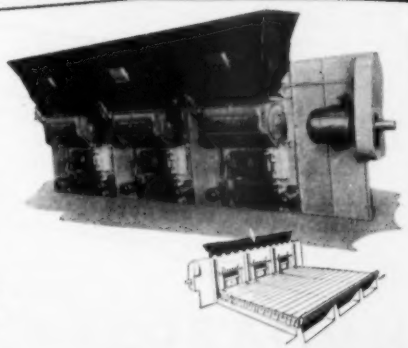
Approximate Application Range—150 to 600 boiler hp.

A single-retort, underfeed stoker designed to burn a wide variety of bituminous coals, particularly those having caking and coking characteristics. The Type E has ram type feed supplemented by a reciprocating sliding bottom. Its grate surface consists of hollow, air-cooled grate bars arranged in an alternately fixed and moving relationship to condition the fuel bed and assure its steady movement to the dump trays which are of the cantilever type. Air supply is under zoned control with provision for introduction of air over the fire. Type E Stokers are available with steam, electric or hydraulic drive.

SPREADER STOKER

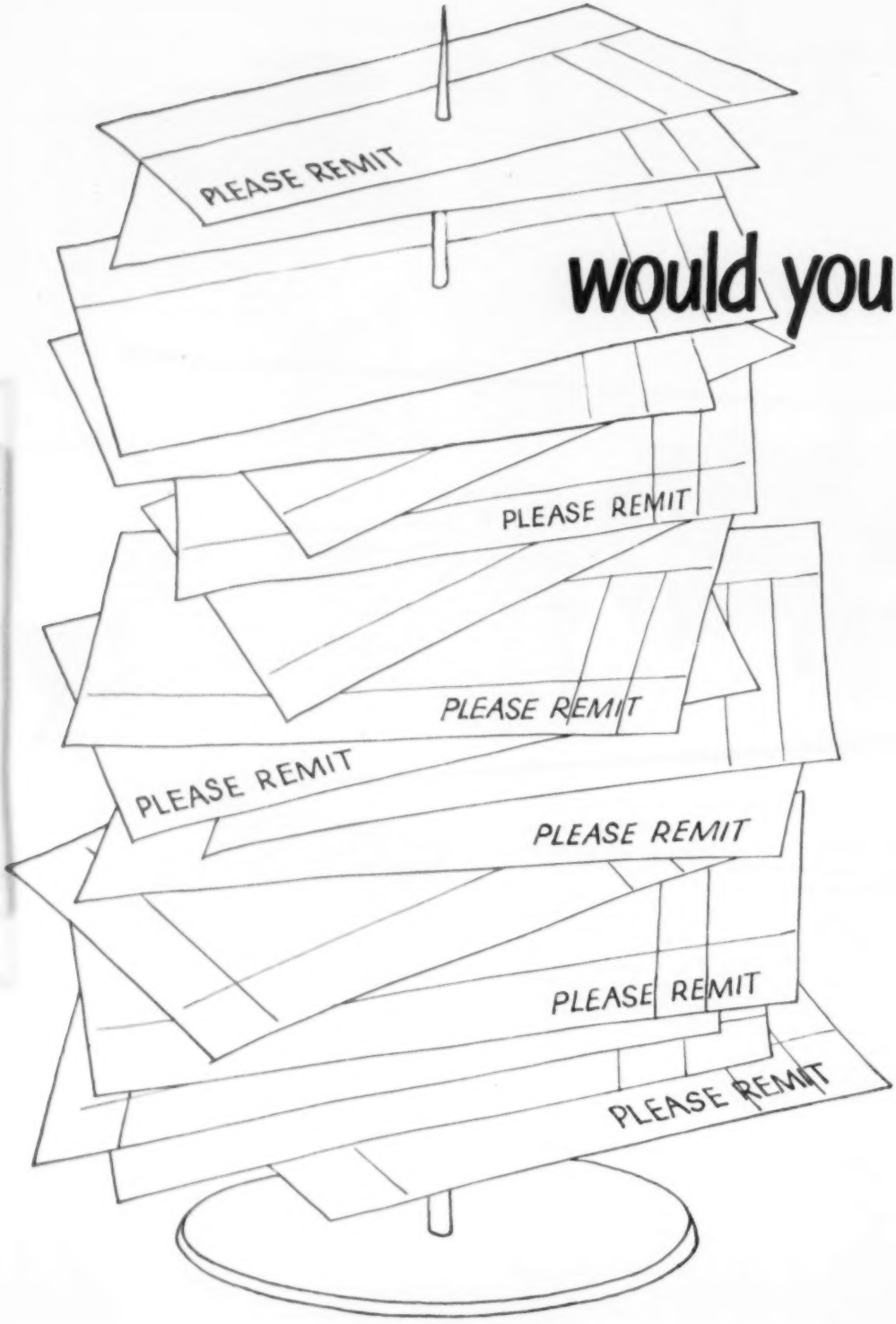
Approximate Application Range—150 boiler hp. up to units producing 200,000 lb of steam per hr, or more.

The C-E Spreader Stoker is available in both dumping grate and continuous discharge types. This simple, rugged stoker is designed to burn a wide variety of coals. Hopper, feeding and distributing mechanism, variable-speed drive and motor are combined in a compact unit. Rotating spreader blades feed coal into the furnace in crisscrossing streams which assure uniform distribution. Fines are burned in suspension and the rest of the coal is burned on the grate. Grate surface is zoned for regulating air admission and to facilitate cleaning. All parts subject to wear are readily accessible for inspection, adjustment or replacement, when necessary. Rate of fuel feed and air supply may be regulated over a wide range and are readily adaptable to automatic control.



— SUPERHEATER, INC.

200 MADISON AVENUE, NEW YORK 16, N. Y.


PLEASE REMIT
would you
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pay 16 times

FOR THE SAME CONTROL SYSTEM?

Of course you wouldn't — but maybe you *do*.

Let's consider a few figures. At a conservative estimate, a good boiler will give you 200,000 hours of service. If it is a 100,000 lb/hr boiler it will burn during that time not less than $8,000,000 worth of fuel—even at today's prices.

If, through failure of your control system to give maximum combustion efficiency, you waste as little as *one per cent* of that fuel, your control system will have cost you $80,000—in addition to what you paid for it originally.

You will still have the same control equipment (you started with)—but you will have paid for it *sixteen times* over!

With a system by Hagan, you pay for your control just *once*. Hagan Automatic Combustion Control Systems are designed for *precise* control. When they are placed in service, they are adjusted by Hagan's experienced combustion engineers, who make sure that you *get* the precision which is built into the control system.

Then, by way of extra dividends, Hagan gives you *long life* and *low maintenance*. The ruggedly built components of the Hagan system last as long as the boiler—and longer. Simplicity of design, using the fewest possible parts, and affording minimum opportunity for wear, makes maintenance especially easy and inexpensive.

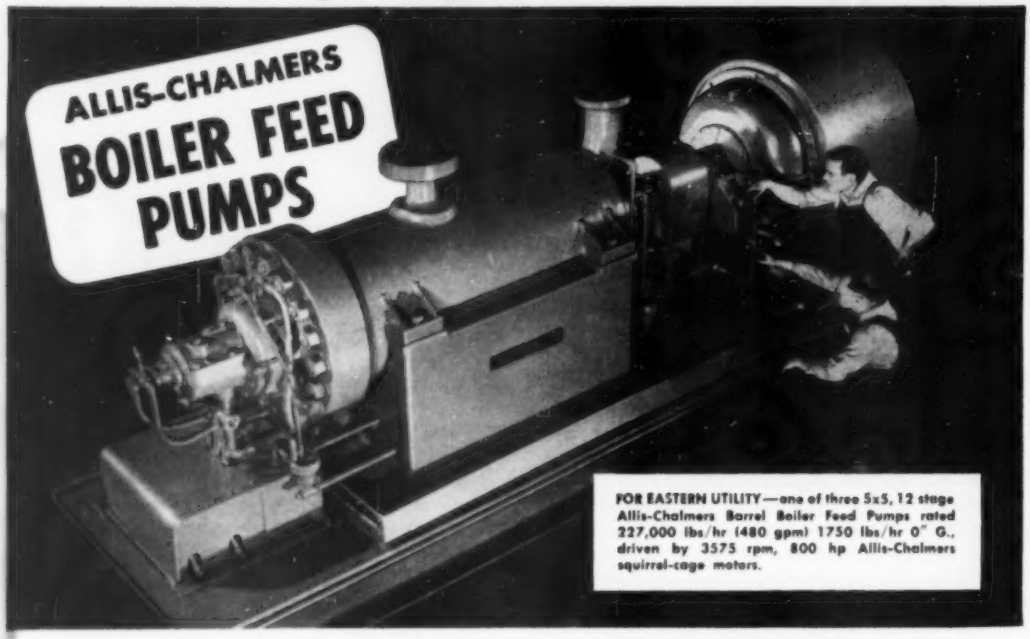
Hagan controls are used on every size of boiler from 5,000 pounds per hour at 3 psi to 1,340,000 pounds per hour at 1800 psi. They have been applied to boilers burning oil, coal, gases of various types, sawdust—and always with satisfactory results.

Our engineers will be glad to give you full information on Hagan control systems. Write to Hagan Corporation, Hagan Building, Pittsburgh 30, Pa.

HAGAN CORPORATION

BOILER COMBUSTION CONTROL SYSTEMS
RING BALANCE FLOW AND PRESSURE INSTRUMENTS
METALLURGICAL FURNACE CONTROL SYSTEMS
THRUSTORQ FORCE MEASURING DEVICES

A Single Responsibility for Pumping Performance!



FOR EASTERN UTILITY—one of three 5x5, 12 stage Allis-Chalmers Barrel Boiler Feed Pumps rated 227,000 lbs/hr (480 gpm) 1750 lbs/hr 0° G., driven by 3575 rpm, 800 hp Allis-Chalmers squirrel-cage motors.

BEAT THIS KIND OF COMBINATION — *at any price:* An excellent quality boiler feed *pump*, high reliability *motor*, and complete *control*—all Allis-Chalmers built and backed!

You save time and money in negotiation, installation and operation.

ASK THE POWER PLANT USER!

Regardless of which of the 3 Allis-Chalmers boiler feed pumps described at right you finally settle on, here's the kind of *maintenance* operational record you can expect and get when you invest in A-C:

EASTERN UTILITY, 735 gpm pumps, "after 45,000 hours no measurable wear on shaft sleeves, rings or internal parts."

MIDWEST UTILITY, 6 x 4, 5-stage pumps, "After 82,000 hours not .001 inch wear on any internal part."

OHIO UTILITY re-ordered three 1800 p.s.i. pumps on strength of this performance — "Only .002 inch wear on rings after 8 years operation on pumps."

And on the motor end, a midwest Utility reports, "in over 20 years of uninterrupted service with three, 800 hp, two-pole motors driving boiler feed pumps we've had to order replacement parts just twice at a total cost averaging less than $12 a year!"

CHOOSE FROM 3 TYPES PUMPS:

☛ Barrel-type, for larger steam stations operating against the higher pressures, 1200 to 2500 lbs; 300 to 2000 gpm.

☛ "Doubleton," for pressures between 1200 and 1800 p.s.i.

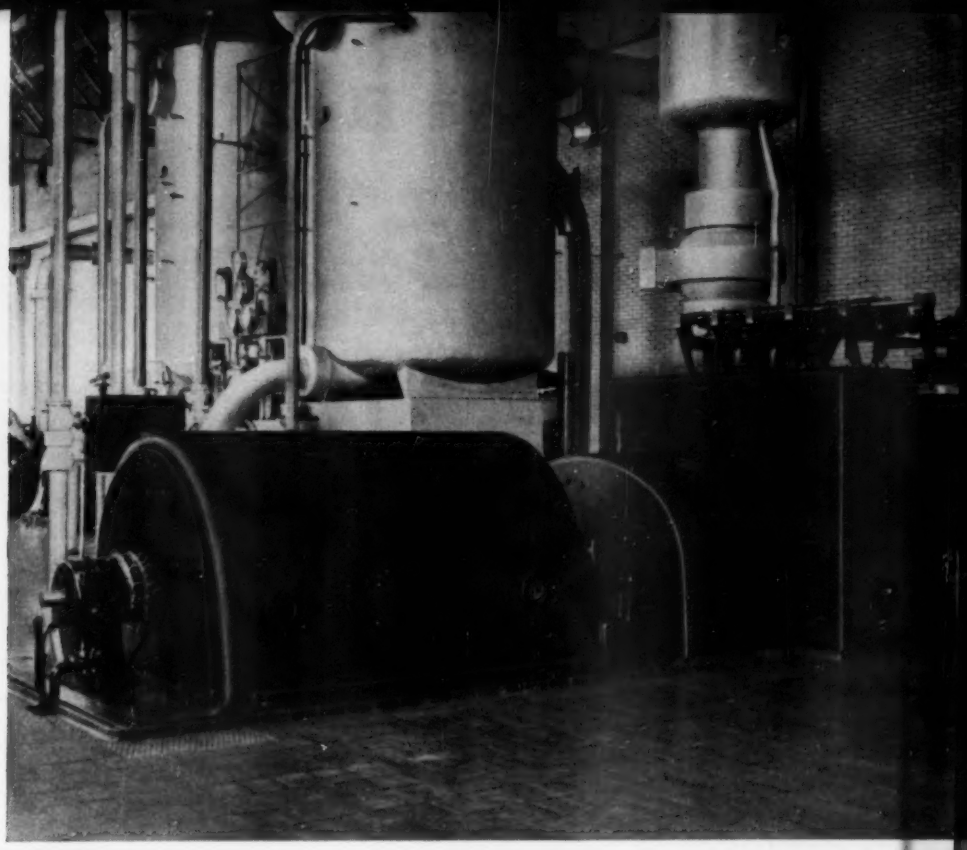
☛ Standard Type "M," for pressures usually under 1200 p.s.i.

BENEFITS OF "PACKAGE" INVESTMENT

Yes, for *quality* performance in *your* power plant, get hold of an Allis-Chalmers pump application engineer today. He's an *expert* at figuring requirements at the economy point. And he's ready to show you *where* and *how* a complete Allis-Chalmers "Power Plant Pumping Package"... pumps, motors, control, will keep you ahead in time, performance, and freedom from worry. A-3040

ALLIS-CHALMERS, 953A SO. 70 ST. MILWAUKEE, WIS.

ALLIS-CHALMERS



Used 18 years, oil goes right back on the job

● In 18 years of operation, the original fill of NONPAREIL Turbine Oil was never removed from this 2500-KW turbine at the University of Michigan power house. Neutralization numbers always stayed below 0.07 mg. KOH/gm. Tests of oil samples showed no deterioration of the lubricant.

Recently, the turbine was shut down for inspection and general overhaul. Operators drained NONPAREIL from the unit and took a close look at the oil system. *They found no oil deposits, no evidence of rust, and not a sign of corrosion.* The oil itself was in excellent condition and after centrifuging it was returned to the turbine for continued use.

You, too, can obtain such lubrication advantages. By switching to NONPAREIL Turbine Oil, you can eliminate oil acidity troubles and oil system maintenance once and for all. These benefits are not only indicated by the experience of others but are backed by the written guarantee you receive that NONPAREIL will last as long as the turbine and that its acidity will stay below 0.15 mg. KOH/gm.

A Standard Oil lubrication specialist will be glad to supply you with actual case histories of utility operations on which Nonpareil Turbine Oil has reduced lubrication costs as much as 68%. To arrange for his visit, write: Standard Oil Company (Indiana), 910 S. Michigan Ave., Chicago 80, Ill.

NONPAREIL
Turbine Oil

STANDARD OIL COMPANY (INDIANA) STANDARD

Here's How to Erase Smoke Troubles

VIOLATION OF SMOKE ORDINANCE

LOSS OF FUEL ECONOMY

BAD COMMUNITY RELATIONS

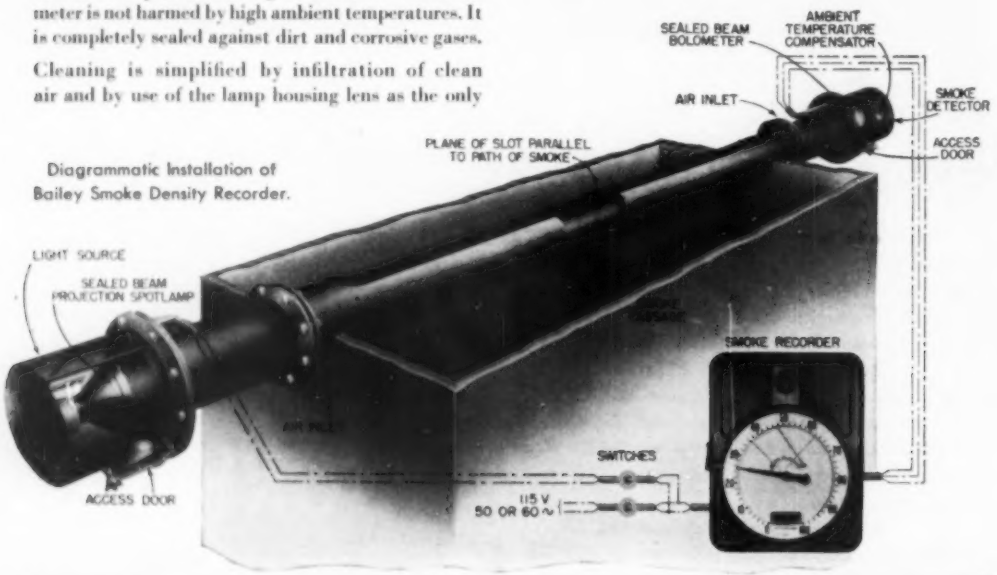
★ One of your first steps in erasing these troubles which result from excessive smoke, should be the installation of a Bailey Smoke Density Recorder. This 24-hour recorder is not an ordinary photo-cell instrument. Instead it detects smoke density by a Bolometer which is simply a sturdy tungsten filament and a parabolic mirror, mounted in a standard sealed beam automobile head lamp housing.

In using this simple, unique smoke detector, you do not have to provide cooling devices since the Bolometer is not harmed by high ambient temperatures. It is completely sealed against dirt and corrosive gases.

Cleaning is simplified by infiltration of clean air and by use of the lamp housing lens as the only window between the Bolometer and the gas passage.

It's easy to secure and maintain alignment of the sealed beam light source with the Bolometer since they are mounted at opposite ends of a slotted pipe which extends across the smoke passage.

For complete information on how you can profitably use this unique instrument to erase your smoke troubles, ask for Bulletin 211, "Bailey Smoke Density Recorder".



Diagrammatic Installation of Bailey Smoke Density Recorder.

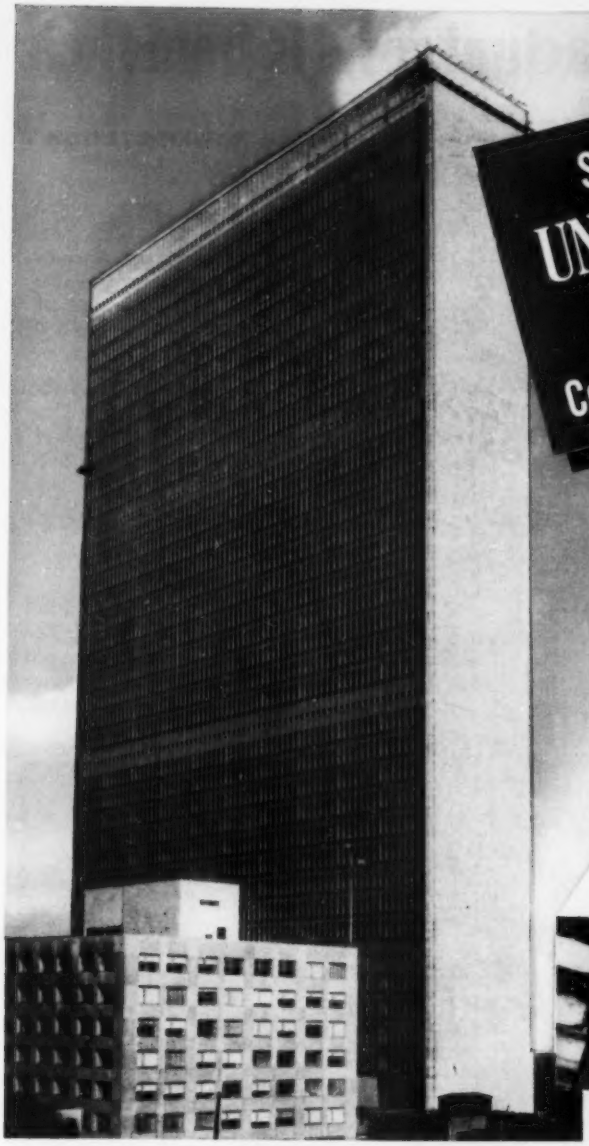
G-29

BAILEY METER COMPANY

1040 IVANHOE ROAD, CLEVELAND 10, OHIO • BRANCH OFFICES IN PRINCIPAL CITIES

BAILEY METER COMPANY LIMITED, MONTREAL, CANADA

Let Bailey Smoke Density Recorders Watch Your Stacks



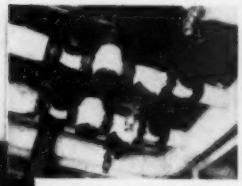
The UN Secretariat was designed by a board of architects from all over the world, with Wallace K. Harrison as Director of Planning, and is being built for the United Nations by Fuller-Turner-Walsh-Slattery, Inc. Sysko & Hennessy were consulting mechanical engineers. Heating, ventilating and air conditioning systems installed by Almirall & Co., Inc.

Steam For Heating UNITED NATIONS BUILDINGS Controlled by Foster Valves

From the Metering Room in the Secretariat Building, steam from New York Steam Corp. is piped at 140 pounds to galleries on the sixth, sixteenth, and twenty sixth floors. Here it undergoes a two-stage reduction and is then distributed for heating service.

Other buildings in this group will also be served from the Metering Room, and steam pressures will be automatically regulated by Foster Valves.

Foster Representatives in principal cities will be glad to work with you on your regulating problems — without obligation.



For the first stage, Foster Type G single seated, internally pilot operated regulators reduce the pressure from 140 pounds to 50 pounds.

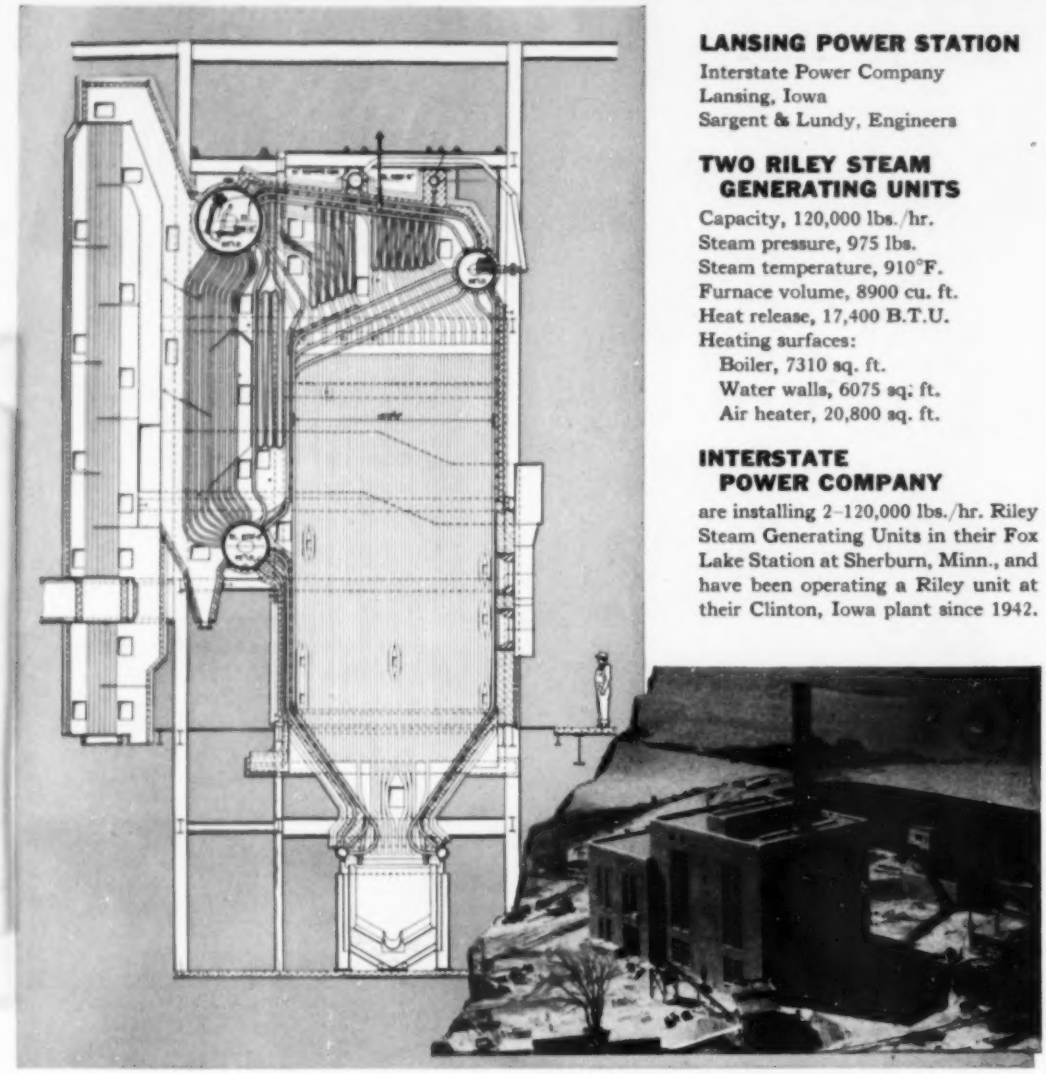
For the second stage, from 50 pounds to 5 pounds, Foster Type J-2 double seated, direct-acting, spring loaded diaphragm valves are used.

FOSTER ENGINEERING Company

PRESSURE REGULATORS . . . RELIEF AND BACK PRESSURE VALVES . . . CUSHION CHECK VALVES . . . ALTITUDE VALVES . . . FAN ENGINE REGULATORS . . . PUMP GOVERNORS . . . TEMPERATURE REGULATORS . . . FLOAT AND LEVER BALANCED VALVES . . . NON-RETURN VALVES . . . VACUUM REGULATORS OR BREAKERS . . . STRAINERS . . . SIRENS SAFETY VALVES FLOW TUBES

835 LEHIGH AVENUE • UNION, N. J.

At Interstate Power, actual results from their



LANSING POWER STATION
Interstate Power Company
Lansing, Iowa
Sargent & Lundy, Engineers

TWO RILEY STEAM GENERATING UNITS
Capacity, 120,000 lbs./hr.
Steam pressure, 975 lbs.
Steam temperature, 910°F.
Furnace volume, 8900 cu. ft.
Heat release, 17,400 B.T.U.
Heating surfaces:
Boiler, 7310 sq. ft.
Water walls, 6075 sq. ft.
Air heater, 20,800 sq. ft.

INTERSTATE POWER COMPANY
are installing 2–120,000 lbs./hr. Riley Steam Generating Units in their Fox Lake Station at Sherburn, Minn., and have been operating a Riley unit at their Clinton, Iowa plant since 1942.

TRADE MARK Rx REGISTERED

RILEY

STOKER CORPORATION, WORCESTER, MASS.

Boston New York Philadelphia Washington Buffalo Pittsburgh Cleveland Detroit Chicago
Cincinnati Atlanta New Orleans Memphis St. Louis Kansas City St. Paul Tulsa Houston
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BOILERS • PULVERIZERS • BURNERS • STOKERS • SUPERHEATERS • FLUE GAS SCRUBBERS

Riley Units exceed guaranteed performance

Progress of the Riley Stoker Corporation in the boiler industry—1948 was the biggest year in Riley history—can be attributed not only to the quality and outstanding performance of Riley equipment but also to the gratifying manner in which Riley handles the entire contract. Users of Riley products know that Riley gives their customers their money's worth and that you can rely on Riley to furnish units which will give entire satisfaction.

Compare actual performance with guarantees at the Lansing Power Station of Interstate Power Company. Note that exit gas temperatures are 13 degrees better than guaranteed, that efficiency is higher and draft and air pressure losses lower. Such performance is typical of what you can expect when you install Riley units.

Comparison of Actual and Guaranteed Performance

	Actual Results	Guaranteed Results
Steam output	122,272 lbs./hr.	120,000 lbs./hr.
Gas temperature		
Leaving boiler	736°F.	765°F.
Leaving air heater	362°F.	375°F.
Air temperatures		
Entering air heater	107°F.	100°F.
Leaving air heater	604°F.	600°F.
Steam temperature	910°F.	910°F.
Draft loss	4.88"	5.40"
Air pressure required	5.90"	6.50"
Heat balance		
Efficiency	84.56	84.00
Losses		
Dry chimney gas	6.13	6.62
Hyd. and moisture in fuel	5.83	5.83
Moisture in air	.15	.15
Unburned combustible	.53	1.30
Ash pit water	.23	—
Radiation, unaccounted for and leeway	2.59	2.10
	100.00	100.00

Investigate results from some of these recent Riley installations

Northern Virginia Power Co.
Riverton Station, Winchester, Va.

Central Illinois Light Co.
R. S. Wallace Station, E. Peoria, Ill.

Arkansas Power & Light Co.
Cecil Lynch Station, Little Rock, Ark.

South Carolina Power Co.
Hagood Station, Charleston, S. C.

New Orleans Public Service Co.
Market St. Station, New Orleans, La.

Ohio Edison Co.
Mad River Station, Springfield, Ohio

Mississippi Power Co.
Plant Eaton, Hattiesburg, Miss.

Iowa-Illinois Gas & Electric Co.
Riverside Station, Davenport, Iowa

Coralville Station
Iowa City, Iowa

Public Service Co. of Indiana
Dresser Station, Terre Haute, Ind.
Edwardsport Station, Edwardsport, Ind.
Noblesville Station, Noblesville, Ind.

Gulf Power Co.
Pensacola Steam Station, Fla.

Houston Lighting & Power Co.
West Junction Station, Houston, Texas
Greens Bayou Station, Houston, Texas
Gable Street Station, Houston, Texas

Central Ohio Light & Power Co.
Woodcock Station, Bluffton, Ohio

Otter Tail Power Co.
Kidder Station, Wahpeton, N. D.
Crookston Station, Crookston, Minn.
Devils Lake Station, Devils Lake, N. D.
Canby Station, Canby, Minn.
Hoot Lake Station, Hoot Lake, Minn.

Southwestern Public Service Co.
Borger, Texas

Pennsylvania Electric Co.
Williamsburg, Pa.

Utah Power & Light Co.
Orem Station, Provo, Utah
Jordan Station, Salt Lake City, Utah

Worcester County Electric Co.
Webster St. Station, Worcester, Mass.

West Penn Power Co.
Milesburg Station, Milesburg, Pa.

Lynn Gas & Electric Co.
Lynn, Mass.

A survey of your Power Plant by a consulting engineer will possibly show ways of making surprisingly l... costs

COMPLETE STEAM GENERATING UNITS

. . . it will pay you to visit modern Riley Installations before purchasing Boiler or Fuel Burning Equipment

ECONOMIZERS WATER-COOLED FURNACES • STEEL-CLAD ... SETTINGS • AIR HEATERS

To you from Garlock Research

—FOR SUPERIOR PERFORMANCE

GARLOCK RESEARCH coupled with modern quality controlled manufacturing processes bring you Garlock Packings, Gaskets and Oil Seals which give superior performance consistently. A few widely used Garlock products are:

1. GARLOCK *Bitan** Leather Packings—tanned and treated by an exclusive Garlock process for severe service.
2. GARLOCK *Lattice-Braid*—a patented braided packing, made of asbestos, flax or cotton—in which all strands are lattice-linked together into a sturdy and flexible unified structure.
3. GARLOCK *Guardian** Gaskets—spirally wound metal and asbestos—are extremely resilient. Recommended for use against the highest temperatures and pressures.
4. GARLOCK *Chevron** Packing—an automatic packing made of asbestos or cotton base materials—accurately molded into rings of any size. Chevron packs high pressure jobs or low pressure jobs with minimum friction and wear.
5. GARLOCK *KLOZURE** Oil Seal Models 53 and 63—tough, durable, resilient. Complete range of sizes, including Metric O.D.

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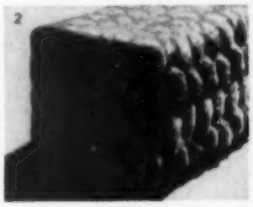
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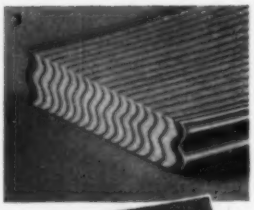
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*Reg. U.S. Pat. Off.

GARLOCK

COCHRANE DEAERATOR

500,000 lbs/hr at LONGVIEW FIBRE CO.

AT LONGVIEW Fibre Company's new high pressure steam and electric plant at Longview, Washington, feedwater for the two 900 lb. boilers is deaerated by the Cochrane Deaerator shown here of 500,000 lbs/hr capacity, operating at 20 p.s.i. steam pressure.

The Longview installation is an interesting one in many respects, both 900 lb. boilers being located outdoors, a practice well-established in the southern Pacific Coast area but not so common as far north as Longview.

The Cochrane Deaerator selected for this important steam plant is additional evidence of the demonstrated performance of Cochrane equipment, not only in the pulp and paper industry, but in steam plants in practically every industry. For information on all phases of the deaeration of water write Cochrane Corporation, 3123 N. 17th St., Philadelphia 32, Pa. In Canada: Canadian General Electric Company, Ltd., Toronto.

COCHRANE CORPORATION 87 YEARS OF SERVICE 1863 - 1950

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From Western Precipitation—the organization that pioneered the commercial application of Cottrell Precipitation...

28 PAGES of helpful facts to know about COTTRELL ELECTRICAL PRECIPITATORS

IF YOU ARE ENGAGED in any phase of industry where the recovery of dusts, fumes, fly ash, mists, fogs or other suspensions from gases is a problem, you will find this booklet on the COTTRELL Electrical Precipitator helpful and informative.

Western Precipitation pioneered and installed the first commercial application of the well-known COTTRELL Electric Precipitator—Dr. Cottrell, the inventor, being a member of the company. And for more than 42 years Western Precipitation has consistently led in developing new COTTRELL advancements and techniques for recovering suspensions from gases, both wet and dry.

This 28 page booklet summarizes many of the basic facts you should know about modern COTTRELL Precipitators—the various types available, how they operate, principal types of electrode systems and rectifiers, shell constructions, etc. As long as the supply lasts, a free copy will be sent you on request to our nearest office. Ask for Bulletin No. C 103.

Packed with helpful COTTRELL Information!

This Western Precipitation Cottrell booklet is designed to answer questions of design engineers, plant engineers and others interested in applying Precipitators to the recovery of industrial dusts and mists. It discusses such subjects as...

- Basic types of Cottrell Electric Precipitators.
- Principal parts of a Cottrell Precipitator.
- Mechanical and Electronic Rectifiers.
- Various types of Collecting Electrodes (rod curtains, corrugated plates, dual plates, pocket electrodes, etc.).
- Removal of Collected Material.
- Factors in Shell Construction (steel, concrete, brick, etc.).
- Operating Efficiencies and the Effect of Various Factors on Performance.

...and many other basic Cottrell facts. Write for your free copy of Bulletin C103 today while supplies are adequate!

Western Precipitation is not affiliated with any other company in the field of electrical precipitation except its wholly owned subsidiaries, International Precipitation Corporation and the Precipitation Company of Canada, Ltd. Whether you are now contemplating the installation of a Cottrell Electrical Precipitator, or may be interested in such an installation at a future date, we can and will serve you in any part of the United States or other countries.

NOW SELLING

COTTRELL Precipitators
MULTICLONE Collectors
TURBULAIRE Spray Dryers

...in all parts of the U.S.A. and foreign countries.

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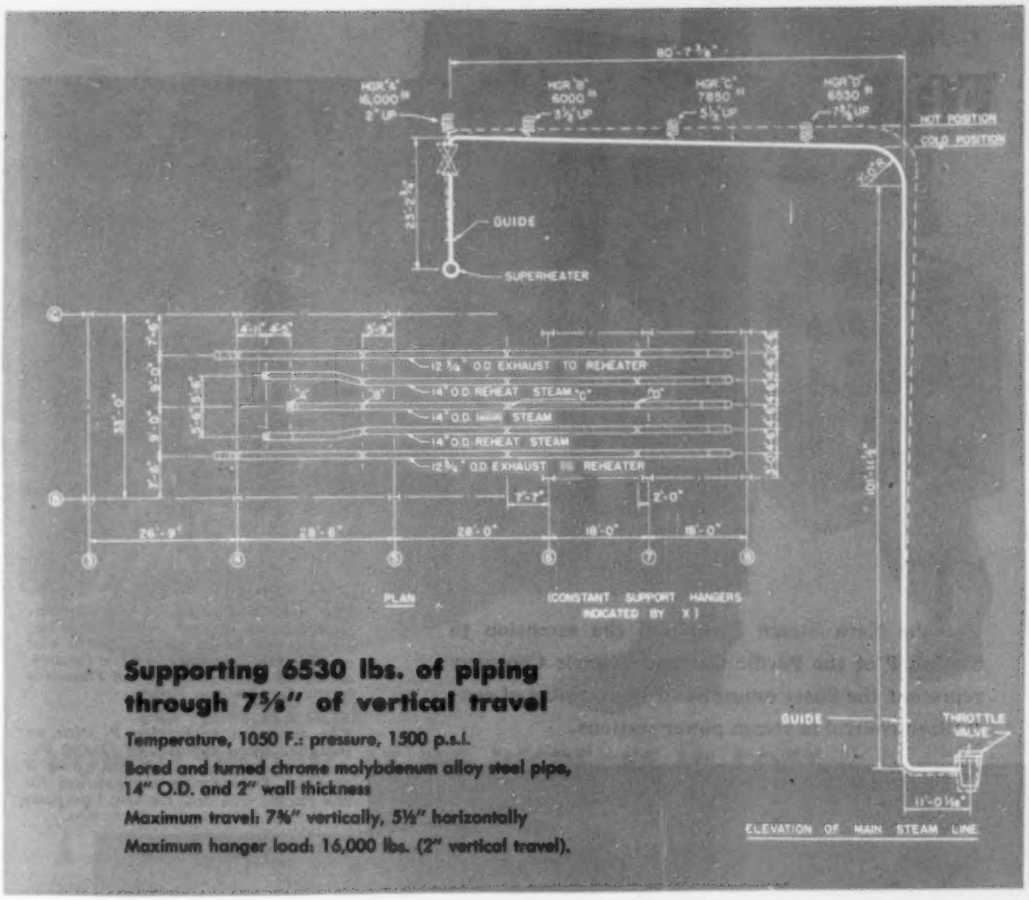

Supporting 6530 lbs. of piping through 7⅝" of vertical travel

Temperature, 1050 F.; pressure, 1500 p.s.i.

Bored and turned chrome molybdenum alloy steel pipe, 14" O.D. and 2" wall thickness

Maximum travel: 7⅝" vertically, 5½" horizontally

Maximum hanger load: 16,000 lbs. (2" vertical travel).

ONLY a Grinnell Constant-Support Hanger solves this problem easily, practically

Provides constant support to piping subject to vertical movement — in all hot and cold positions. Maintains full safety factor in supporting high temperature, high pressure piping. Non-resonant and energy absorbing. Mass-produced from standard precision parts. Individually calibrated for each installation. Load-adjustment features incorporated into design. Models to meet entire range of load-travel specifications. Minimum headroom required.

Believing that a good piping job is too important to be jeopardized by improvised or inadequate pipe hangers, Grinnell has developed a complete line of stock hangers and supports for every piping need from a simple water pipe to a high pressure, high temperature steam line. Write for Catalog 10-D.

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FOR P·G·and E·

The Kern Steam Plant and the extension to Station P of the Pacific Gas and Electric Company represent the finest examples in the country of centralized control in steam power stations.

The Kern Steam Plant, with an installed rated capacity of 175,000 kw, recently completed for the Pacific Gas and Electric Company in Kern County, about 300 miles south of San Francisco in the San Joaquin Valley.

The extension to Station P, with an installed rated capacity of 222,000 kw, designed and constructed by Stone & Webster Engineering Corporation for the Pacific Gas and Electric Company at Hunters Point, San Francisco.

STONE & WEBSTER ENGINEERING CORPORATION

A SUBSIDIARY OF STONE & WEBSTER, INC.

Call in this Remarkable Instrument

TO INCREASE POWER OUTPUT AT NO INCREASE IN COST

THE Cities Service Industrial Heat Prover is a flue gas analyzer which quickly, accurately and completely determines the heat generating efficiency of equipment using any type of fuel. With this information necessary adjustments to increase efficiency can be made.

A complete new line of petroleum products for the power field including:

- **D-C Diesel Engine Oils**
- **Pacemaker, Turbine and Compressor Oils**
- **Optimus Cylinder Oils**
- **Sentry Plant Machinery Oils**

The Heat Prover gives you the answers to these questions important to efficient production:

1. **How much energy is wasted in uselessly heating excess air?**
2. **How much excess oxygen is present in furnace gases?**
3. **What percentage of fuel is converted into useful heat?**

For a complete description of Cities Service Industrial Heat Prover Service, mail the coupon below for your copy of "Combustion Control for Industry."

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QUALITY PETROLEUM PRODUCTS

CITIES SERVICE OIL CO.
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New York 5, N. Y.
Please send me without obligation your new booklet entitled "Combustion Control for Industry."

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DOUBLE *Strength!*
DOUBLE *Value!*

300# valve qualities
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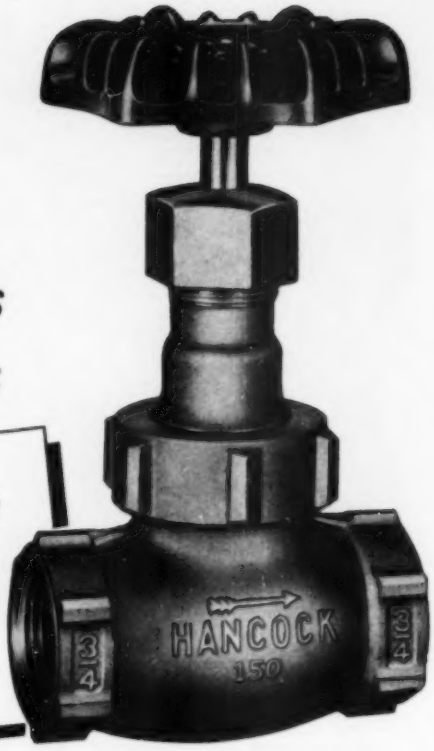
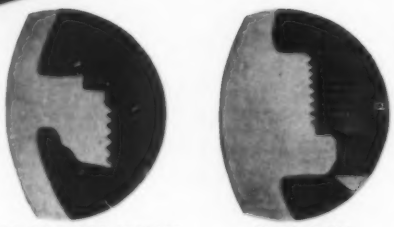


The New 150# Hancock "500 Brinell" Bronze Valve



USUAL BRONZE VALVE DIAPHRAGM | **HANCOCK DIAPHRAGM**

Diaphragm construction of the new 150# Hancock Bronze Valve is *125% to 230% stronger* than found in usual bronze valves.

Here's the bronze valve for greatest service, greatest savings.

Note, for example, the diaphragm construction equal to that of a 300# bronze valve—for strength, rigidity, freedom from leaks, long service life.

Add the fact that the "500 Brinell" stainless steel seats and discs—near diamond-hard—eliminate wire drawing, steam cutting, erosion and corrosion and you'll have the reasons why maintenance is cut to a minimum.

These new valves are super tough! They really stand up to the hardest installation and piping strains, expansion in piping systems.

Before you specify, compare the new 150# Hancock Bronze valve *with any other make*. You're sure of *double savings* if you do.

New 150# Hancock Bronze Valves are available at your local Hancock distributor

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BURROUGHS ADDING MACHINE COMPANY

have used DETROIT STOKERS for 33 years

Burroughs Adding Machine Company Plant—Detroit, Michigan. Designed by Albert Kahn Associated Architects and Engineers.

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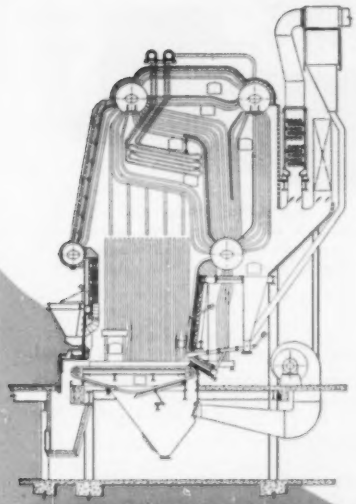
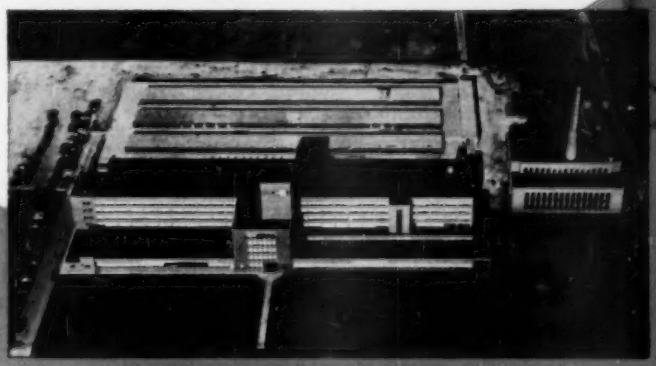
The Keynote of Burroughs Buying Policy

As the Burroughs business has expanded through the years, calling for more capacity; and as fuel specifications have changed, they have continually modernized with Detroit Stokers. Burroughs Plants at Detroit and Plymouth, Michigan, use Detroit RotoGrate and RotoStokers exclusively. A wide range of bituminous coal and coke breeze is efficiently burned.

Why not modernize your plant to reduce steam costs. Our recommendations entail no obligation. Write for information.



Latest Burroughs installation, Detroit RotoGrate Stoker with Union Iron Works Steam Generator.



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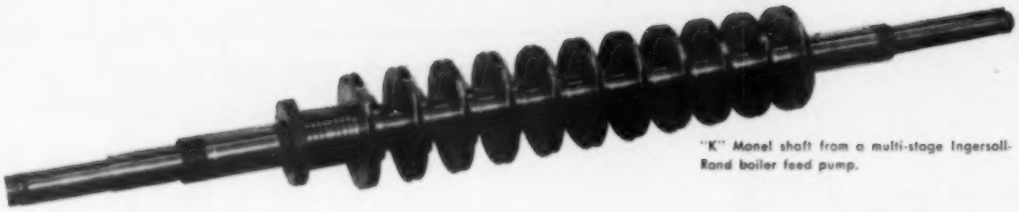


"K" Monel shaft from a multi-stage Ingersoll-Rand boiler feed pump.

"K" MONEL FOR PUMP SHAFTS...

Corrosion-resistant? *Yes!*

Heat-treatable *after* machining? *Yes!*

Strength and hardness close to alloy steel? *Yes!*

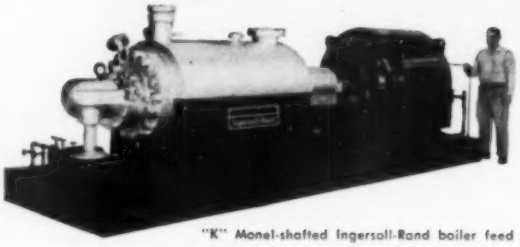
"K" Monel . . . an alloy that may be heat-treated to attain maximum properties . . . has several important qualities that recommend it particularly for pump shafts.

In many pump designs, the shaft must be long and thin, yet capable of withstanding extreme loading as well as highly corrosive conditions. This combination of design factors demands a shaft metal that possesses high strength and hardness, unusually high resistance to corrosion, and high resistance to corrosion-fatigue.

"K"® Monel meets these requirements successfully, and in addition offers the advantage that it may be heat treated for high strength and hardness *after* machining without undue distortion.

Typical installations of "K" Monel-shafted pumps are those of the American Gas and Electric Company System. At three central stations, located in West Virginia and Indiana, a number of Ingersoll-Rand multi-stage pumps are used for boiler feedwater injection.

These pumps operate against a boiler pressure of 2000 psi and higher, and handle water at an average temperature of 304 F. Each pump delivers 1100 gallons per minute at a total dynamic head of 6000 feet.



"K" Monel-shafted Ingersoll-Rand boiler feed pump of the type used by the American Gas and Electric Company System. Manufactured by *Ingersoll-Rand* Company, Phillipsburg, N. J.

These severe conditions demand a shaft metal that is strong, wear-resistant, and corrosion-resistant. Heat-treated "K" Monel has proved entirely satisfactory in this service.

If you are concerned with pump purchase or maintenance, you will be interested in "*How to get longer life from your pumps.*" Write to R. F. Johnson of INCO for your free copy.

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BIDDLE *Instrument News*

- ELECTRICAL TESTING INSTRUMENTS
- SPEED MEASURING INSTRUMENTS
- LABORATORY & SCIENTIFIC EQUIPMENT

NUMBER 1 OF A SERIES

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A *NEW* CONSTANT-VOLTAGE TYPE MEGGER® INSULATION TESTER IN LOW-PRICED RANGE

The trim, modern design of this newcomer to the Megger family of insulation resistance testing instruments is only part of the story. Ohm scale and selector switch are available on all instruments in ranges of 0 to 10 megohms, 100 volts d-c, 0 to 20 megohms, 250 volts d-c, 0 to 50 megohms, 500 volts d-c. The constant-voltage feature is standard with all of these new CVM (Constant Voltage Type Megger) Insulation Testers. These features plus several other mechanical refinements contribute to make this instrument a worthy addition to the popular line of Megger Instruments.

Bulletin 21-80-PG, describing this instrument, will be sent on request. Check the coupon below.

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. . . only if they have low resistance

MEGGER® GROUND TESTING INSTRUMENTS PROVIDE EASY MEANS OF MEASUREMENT

Many seemingly good ground installations offer little protection since high earth resistance renders them ineffective.

There is no assurance that earth resistance will remain constant. It is therefore important that grounds be checked regularly by a reliable, accurate means.

Megger Ground Testing Instruments provide the means in one portable-easy-to-use instrument, for measuring resistance to earth of ground connections, such as rods, pipes, buried plates, and metallic structures. The method is quick, easy and economical—no calculations or adjustments are necessary—anyone can make tests—direct readings are taken in ohms from the scale and pointer.

Fileworthy literature on the subject of Ground Resistance Testing is available without obligation. Write for Bulletin 25J-PG which gives instructions and diagrams, or Bulletin 25T2-PG, "Grounding Electrical Circuits Effectively" by J. R. Eaton.

THE T-21 MEASURES SPEED SIMPLY BY TOUCH—OR BY MOUNTING ON MACHINE

This new low-priced, miniature FRAHM® Resonant Reed Tachometer is available singly or in kits of three instruments; for hand use or permanent mounting; in ranges from 900 to 13,000 rpm, higher ranges on request.

The T-21 has the advantage of being small and easy to use as a pocket or tool kit instrument and yet easy to read when mounted on a machine. It has no parts to wear out, needs no maintenance, imposes no load on the machine under test, nor can it be damaged by overspeeding.

The simplicity of this resonant reed instrument in no way affects its accuracy—Frahm Tachometers are guaranteed to within 0.5% of their rated frequency of vibration.

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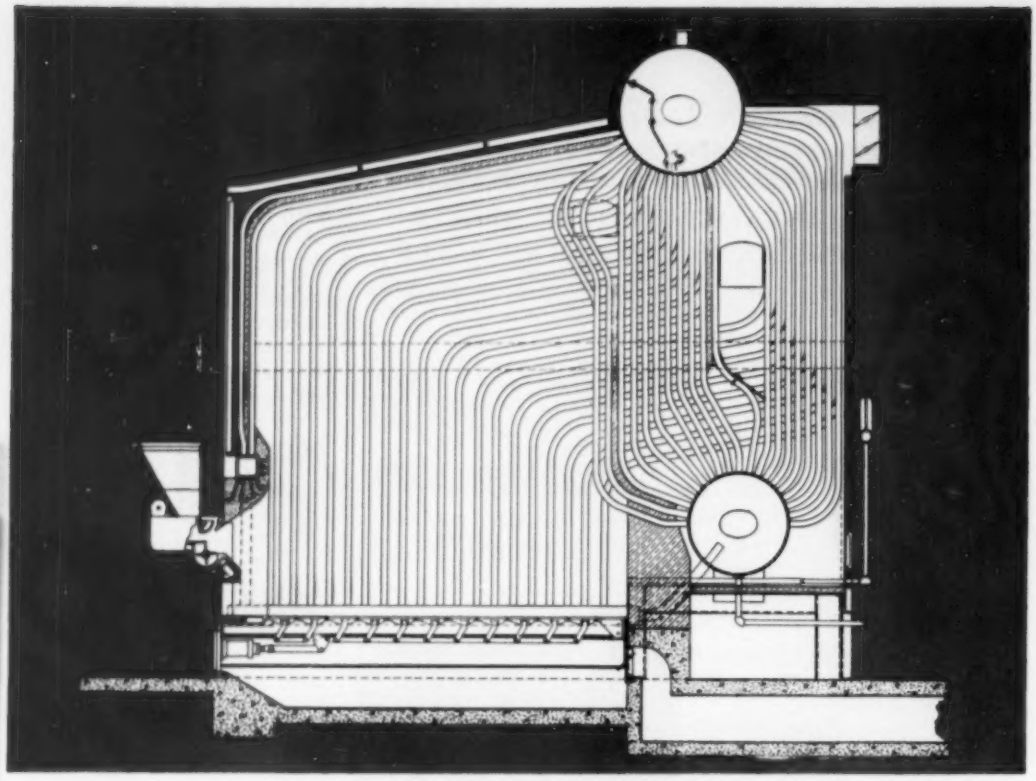

THE *V-C* 2-DRUM *High Capacity • Small Space*

COMBINING BOILER • WATER WALL FURNACE • INSULATED STEEL CASING

ERIE CITY concentrates high capacity into small space. The V-C Steam Generator has complete water cooling of top, sides and front, integral with a 2-drum boiler.

GAS travel is symmetrical about the center line of the unit.

WATER circulation is ring flow.

ONE or two internal steam separators, as required, assure clean, dry steam.

THE entire unit is supported from bottom members, thus allowing free expansion upward of the entire unit. All exterior walls consist of insulated steel panels, independently suspended, a construction similar to that of our largest central station steam generators.

ANY tube can be replaced without disturbing any other tube.

THE above illustration shows an Erie City Spreader Stoker fired V-C unit, utilizing a water cooled plastic arch, molded around the front header.

THE Erie City V-C Steam Generator is available in a wide range of capacities for varying space limitations and for all firing methods. Write for bulletin 37.

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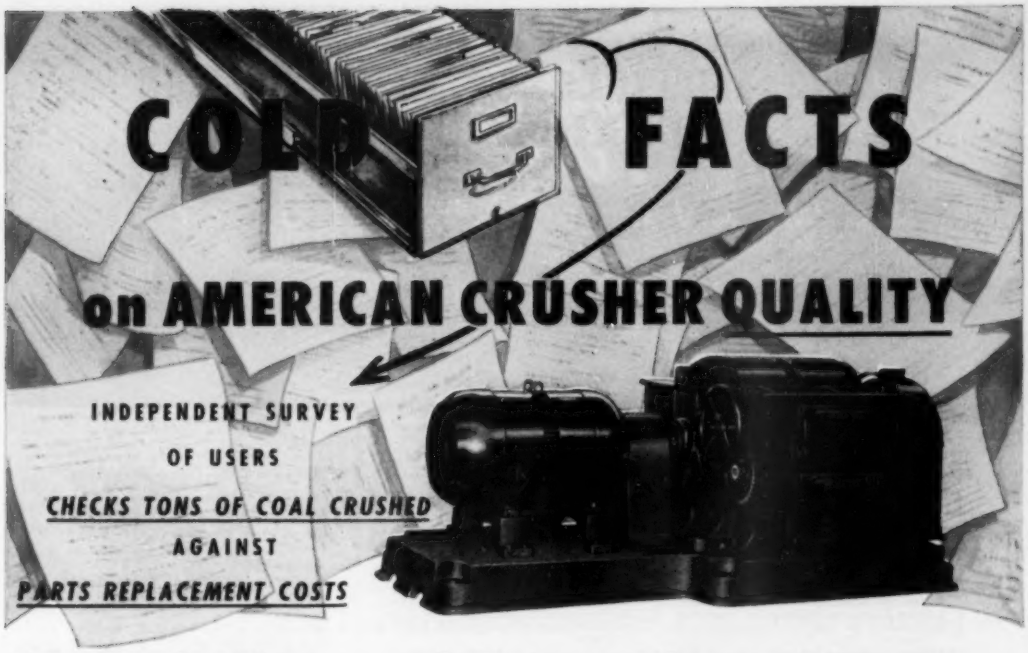

29 Coal Mines and Power Plants Report . . .

1. A total of 61,161,372 tons crushed.
2. Average age of American Crushers at time of survey—9.35 years.
3. Average parts replacement cost $.0012 per ton (includes cost of standby parts not yet needed).

CONCLUSION:

AMERICANS CAN "TAKE IT"! NEEDING NEW PARTS *LESS OFTEN*, THEY KEEP OVERALL PRODUCTION EFFICIENCY *HIGH*.

HERE ARE A FEW CASE HISTORIES

A Coal Mine in Illinois reports 4,000,000 tons crushed over 10-year period by their American AC3-E Crusher —with a parts replacement cost of $.0005 per ton.

An Industrial Power Plant in West Virginia has an American 38-S Crusher that has reduced 10,008,000 tons over last ten years. Parts replacement cost was only $.0008 per ton.

A Central Station in New Jersey crushed 6,000,000 tons over a 20-year period with their American 42-S. Parts replacement cost was only $.00025 per ton. Crusher still going strong.

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- ☐ Six Methods for Controlling Corrosion Rates of Metals – H. H. Uhlig, Associate Professor of Metallurgy, Massachusetts Institute of Technology. (2 pages)
- ☐ Causes and Prevention of Condensate Return Line Corrosion – R. T. Hanlon, National Aluminate Corporation (4 pages)
- ☐ Nalco Corrosion Inhibitor for Preventing Corrosion by Salt Used on Streets and Highways – Nalco Bulletin No. 44 (4 pages)
- ☐ Nalco Corrosion Inhibitor – Use of Test Panels on vehicles for evaluating benefits of corrosion inhibitors with roadway salt – Nalco Bulletin No. 45 (4 pages)

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- ☐ Stanolind No. 5 Uses Hot Process on 100% Makeup for 1500 P.S.I. Boilers – Glenn R. Hull, General Foreman, Utilities and Conservation Division, The Whiting Refinery, Standard Oil Company (Indiana) (4 pages)
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ELECTRICAL

101 **Enclosures Built to Order**—Bulletin EE, 16 pp, contains over 40 illustrations and descriptions of custom built sheet metal electrical enclosures for power plants, utilities, industrial plants. Among many items illustrated are control desks, cubicles, electrical cabinets, power distribution and control panels, switchgear housings, louvres, test stands, controls and desks, outdoor electrical enclosures, transformers, tanks and instrument panels. The Kirk & Blum Mfg. Co.

102 **Selenium Rectifier Engineering Data**—Selenium power rectifiers applicable to any industrial requirement where direct current is necessary are presented in Bulletin 300, 16 pp. Life expectancy, overloads, ambient temperatures, aging are discussed. Five types of these rectifiers are described in detail along with their special features, regulation, power factor, circuit employed. Accurate Engineering Co.

103 **Soldered Porcelain Potheads**—Bulletin AA50, 16 pp, lists company's complete line of gasketless potheads for protection of cable ends, illustrating their design and including sizes and prices. Contains information on use and construction of stress relief cones and an outline of company's process for soldering metal to porcelain as well as complete electrical and mechanical specifications for 5 to 69 kv single and multiple conductor units. G & W Electric Specialty Co.

104 **D-C Generators**—Outstanding design and construction features of built-to-specification d-c generators for lighting and power supplies are illustrated by photos and discussed in 4-pp Bulletin 41-200. Several complete assemblies are also pictured. The Electric Products Co.

105 **Reversing Motor**—Form HC 4901, 4 pp, in color, covers the company's new 1/3 hp, 1725 rpm, 115 v, single phase motor incorporating the new Reverswitch which provides instant reversal at the flip of a swich. Motor starts in either direction. Made in NEMA No. 56 frame size. Prices included. Iron Fireman Mfg. Co.

106 **Selenium Rectifiers**—This 4-pp bulletin stresses the advantages of metallic dry plate selenium rectifiers for supplying d-c power to a wide range of industrial equipment. Illustrated with photos of complete assemblies and elements, it discusses rectifier's design, cooling, rectifier circuits, giving sizes and ratings. Syntron Co.

INSTRUMENTS AND CONTROLS

107 **Remote Reading Flow Meters**—Data Book 702, 32 pp, fully illustrates and explains flow measurement problems and offers suggestions for their solution. Meter bodies, differential devices and reading instruments are fully described and a special section is included on wide range and reverse flow. Numerous illustrations relate an informative pictorial story on fluid flow measurement. Republic Flow Meters Co.

108 **Insulation Testers**—Bulletin 4A, 4 pp, describes company's lightweight high potential insulation testing instruments for indications of breakdown, leakage and short circuit. Gives details on the operation and simplicity of use of these testers, which have ranges from 0-1500 to 0-6000 v a-c with capacities from 40 to 140 va, and are suitable for random testing and other uses. Associated Research, Inc.

109 **Want to Rent an Instrument?** Here's an interesting booklet describing a rental service for such instruments as a-c ammeters, a-c and d-c voltmeters, recording wattmeters, current transformers made by leading manufacturers. Explains rental fees and rental periods, packing and shipping procedures, and includes a form for requesting further information on specific instruments. InstruRental Co.

110 **Engine Indicator**—Leaflet 611, 2 pp, covering company's free-rotating drum type indicator for high speed engines, explains how this indicator is designed to record a complete pressure-time diagram in a single engine cycle. Illustrates some typical pressure-time diagrams. Discusses and illustrates connection assembly, drum, pistons and springs. Bacharach Industrial Instrument Co.

BOILER MAINTENANCE

111 **Embrittlement—and What To Do About It**—The current status of embrittlement, its causes and control, is discussed in Bulletin 28X7466, 4 pp. Tells how to distinguish between steam boiler cracks caused by corrosion-fatigue and embrittlement, explains prevailing conditions that cause intercrystalline cracking of boiler metal, and describes recent developments including use of nitrates as efficient embrittlement inhibitors and the use of the embrittlement detector unit. Allis-Chalmers Mfg. Co.

112 **Questions and Answers on Boiler Feedwater Problems** — This revised and highly informative Bulletin 30, 16 pp, contains concise, helpful answers to more than a hundred questions about boiler feedwater, its special requirements, problems involved in treating, and practical solutions to these problems. Educational in purpose, the booklet contains no advertising. Explanations cover various water treating methods and their advantages. National Aluminate Corp.

113 **Boiler Water Treatment** — A 4-pp bulletin in color discusses Borgans, a newly developed water treatment, and its use for prevention of scale, silica, corrosion, foaming and oil trouble in boilers and the entire steam and condensate system. The treatment is said to be simple in application, odorless, safe. Chemical Div., Portland Shingle Co.

TRAPS, STRAINERS, STEAM EQUIPMENT

114 **Steam Hook-Ups**—This is a recently published 64-pp sixth edition of company's excellent manual on hook-ups for steam traps, air vents and industrial temperature controls. In addition to hook-up

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diagrams, much helpful technical information is provided covering calculations for steam trap sizes, selection data on traps and regulators, properties of saturated steam, flange standard dimensions, standard pipe and pipe threads. Includes photos and brief discussions of several traps, strainers and other equipment. Copies of this book are offered free to power engineers who make requests on their firm's letterhead addressed to this magazine. Sarco Co., Inc.

115 **More Data on Strainers**—In response to a demand for a former publication on pipeline strainers, this revised edition, Bulletin S-203, 6 pp, is now available. It contains greater and more up-to-date data on screwed strainers as well as expanded details on flanged types. Fully illustrated with photos of the strainers and screens used in them, it explains function of the strainers and provides material specifications, pressure and temperature data, dimensions and prices. Also tells how to install strainers and replace screens. Yarnall-Waring Co.

116 **Steam Calorimeter**—Bulletin 118, 4 pp, discusses an improved U-path calorimeter combining a throttling, separating and re-evaporating calorimeter in a single chamber. Explains and illustrates construction and operation of the unit and quotes letters from users of this type of equipment. Ellison Draft Gage Co., Inc.

117 **Steam Circulation Analyzed**—Technical Bulletin 4, 8 pp, is a discussion of steam circulation systems and is liberally illustrated with engineering drawings. Treats such subjects as steam and condensate velocity, flow, ways of increasing air condensate film velocity, steam circulation, internal construction of steam space and applications for steam circulation pipe heaters. Sarco Co., Inc.

PUMPS

118 **How to Solve Pumping Problems**—Form 3000 is an excellent 136-pp manual on the selection and use of pumps. Lists more than 150 liquids and tells type of pump construction best suited for handling them. Explains how to determine proper size, how to compute suction list and discharge head, to estimate horsepower required, to determine direction of rotation and size and speed of pulleys or gears. Contains instructions for installing rotary pumps, locating trouble in pump installations, and care of pumps, as well as ordering of parts. Also includes numerous technical data tables covering such factors as viscosity conversion, friction loss in pipes, pipe sizes for long runs, suction lift at different altitudes. Geo. D. Roper Corp.

119 **Facts About Rotary Pumps**—Six-pp Bulletin 307 illustrates design, construction, maintenance operation and application of rotary pumps of 5 to 1500 gpm capacity. Details of sliding vanes and swinging vanes with selection table for specifying and other data — capacities, pressures, temperatures and weatherproof features—are included. Blackmer Pump Co.

120 **Cycloidal Vacuum Pumps**—Bulletin 50-B-13, 12 pp, describes a type of positive displacement pump designed especially for heavy-duty suction service and capable of producing vacuums from 4 to 28 in. Hg, with high volumetric efficiency. Structural advantages of the pumps are discussed and illustrated by drawings and performance curves. There is also a discussion of a compound unit, accompanied by piping layout. Ten installation photos are included as well as pictures and descriptions of related equipment. Roots-Connersville Blower Corp.

121 **Centrifugal Pumps**—Bulletin AL-747 presents single-stage, side suction centrifugal pumps of both enclosed impeller and semi-open impeller design. Includes selection tables and full dimensional data, also complete information on the installation and operation of the pumps. Also provides parts lists and tips on what to do in case of unsatisfactory pump performance. Bell & Gossett Co.

122 **Controlled Volume Pumps**—Bulletin 450 presents company's air cylinder powered chemical pumps, automatic chemical feed systems, and automatic hydrostatic test pressure systems for controlled volume pumping at constant speeds, proportional rates and high pressures and for blending, feeding applications. Design details advantages and flexibility of the pumps and their operation are explained and many types of installations are illustrated. Includes capacity-pressure tables, also photos and brief descriptions of auxiliary equipment. Milton Roy Co.

VALVES

123 **Bonnet Valves** — Company's "Pressure-Seal" bonnet valves are described and illustrated by photos and cutaway drawings in Form AD-1819, 12 pp. Includes sizes, dimensions, ratings and tests for gate, globe, angle and stop check valves as recommended for high pressure and high temperature service. Also explains operating advantages of the valves and tells how the pressure seal is made. Photos of several installations included. Crane Co.

124 **Non-Return Valves** — Illustrated Bulletin S-1 is a 6-pp instruction booklet on company's triple acting stop and check valves. Includes complete technical description, engineering diagrams of the three different body and type patterns, a parts list and operation and installation instructions. Golden-Anderson Valve Specialty Co.

125 **Automatic Valves**—In Bulletin 283, 8 pp, are introduced manufacturer's new and improved automatic valves—a pressure reducing and regulating valve, high capacity pressure reducing valves and a reseating relief valve for temperature and pressure. Discusses design, construction and function of the valves, includes sizes, prices and capacity tables. Illustrated with photos, sectional drawings. A. W. Cash Valve Mfg. Corp.

126 **Sampling Valves**—Technical Information Bulletin 4, 4 pp, covers corrosion resistant sampling valves for 150 and 300 lb service. Cutaway illustrations show design and construction of three types. Dimensions, available materials and working pressures are listed. Alloy Steel Products Co., Inc.

127 **Relief Valves**—Company's safety relief valve is described in pocket-size Bulletin S-17. Explains applications for this type of valve, shows how it operates under normal and emergency conditions and lists special features. McDonnell & Miller, Inc.

DUST COLLECTING

128 **Dust Collectors**—Here's a 4-pp bulletin describing dust collectors for boilers fired with coal, lignite, bark, wood and bagasse for use in power plants, cement plants, mills and similar industries. Illustrates and explains operation of a collector with end inlet and top outlet. Discusses flexibility efficiency and other advantages of these dust collectors, lists some recent installations. Bubar Systems, Inc.

129 **Dust Collecting**—Ten reasons why manufacturer's dust collectors afford high efficiency and economical operation are discussed and illustrated in 16-pp Bulletin 152. Among these are power savings, easily installed and inspected tubes, longer cloth life, and fast shaking. Several installations of this equipment are pictured. American Wheelabrator & Equipment Corp.

MATERIALS HANDLING

130 **Belt Conveyor Data** — Catalog RF provides 40 pp of application and engineering data on sectional truss belt conveyors. Main sections cover typical uses for the pre-fabricated sections, in-

(Continued on page 124)

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There can be no mistake in reading boiler water level when the Diamond Bi-Color Water Gauge is used. By reason of the unvarying optical law employed, water always shows green—steam always shows red. The contrast is unmistakable . . . and there is no time lag. There are no moving parts. No linkages or extra piping are used and variation in the specific gravity of the water has no effect whatever.

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Diamond Bi-Color has proved its value through many years of successful operation in thousands of boiler plants. Write for Bulletin 1015.

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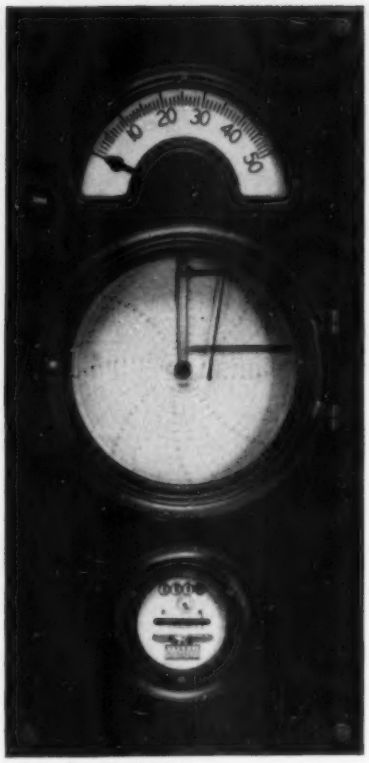
Integrator

Varying flows are accurately totalized because the integrator is continuous



Indicator-Recorder-Integrator

The Republic flow integrator, being of the modified watt-hour type, totalizes continuously—not intermittently. It operates independently of the recorder and its accuracy is not dependent on or affected by any clock mechanism or mechanical action.

The Republic meter is, on this account, peculiarly fitted to follow all changes in flow rate and accurately measure highly fluctuating flows.

ALL TYPES OF FLUIDS

Republic electric type flow meters are available for measuring the flow of all types of liquids and gases. Meter bodies are built for metering fluids at line pressures up to 5,000 lb. per sq. in. and for all ranges of differential pressure. The reading instruments—indicator, recorder and integrator—are of the remote reading type and can be located any distance from the point of flow measurement.

ANY COMBINATION

While each Republic reading instrument is standard in design and construction each is especially calibrated for the particular flow measurement for which it is specified. Any reading instrument, indicator, recorder or integrator, may be obtained separately or in any combination desired, making possible the highest degree of flexibility in plant use.

SIMPLE IN OPERATION

The Republic electric meter is the only flow meter commercially manufactured which is strictly electric in its operation. All other types of so called electric meters use the motion of the mercury to move a float or produce a force which is then converted into an electrical value which is in turn transmitted to a receiving or reading instrument. In the Republic meter, the transmitted electrical value is determined directly by the mercury motion, thus eliminating one of the steps in the sequence, and simplifying the mechanism to that extent. There are no floats, levers, cams, rotating shafts or anything else to interfere with the unimpeded movement of the mercury, which has no work to perform, but merely fulfills the function of making contact.

NEW DATA BOOK

Just off the press—a completely new data book describing and illustrating, in detail, the operating features of the Republic Flow Meter and its many applications. Write for your copy of Data Book No. 702—there is no obligation.

REPUBLIC FLOW METERS CO. ● 2240 DIVERSEY PARKWAY • CHICAGO 47, ILLINOIS

WHIRLING MILESTONES

De Laval today offers a centrifuge for every purification need in the power field. Back of every recommendation stands nearly three-quarters of a century of being ***first*** in major centrifugal developments.

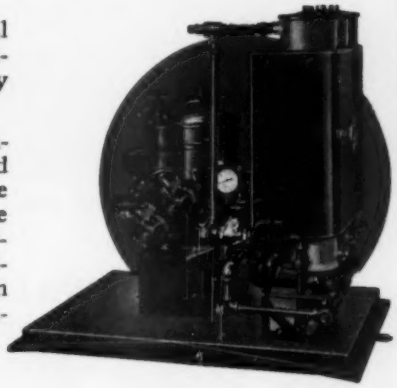
1878 Carl Gustav De Laval invented the first continuous Cream Separator. He tried tubular bowl design.

1890 Dr. De Laval abandoned tubular bowl, invented slower-speed disc bowl to stratify liquid for more efficient purification.

1918 First centrifugal Oil Purifier introduced by De Laval. This continuous Oil Purifier was driven by a small steam turbine.

1922 First De Laval centrifugal Insulating Oil Purifier installed. In 1950, the centrifuge is still the safest way to maintain insulating oil because water, once discharged, cannot recontaminate the dry oil.

1950 Full range of "Uni-Matic" Oil Purifiers now available, including No. 67 with a capacity of approximately 450 gph.



De Laval "Puri-Filter," combining centrifugal force and filtration, makes possible the removal of fly ash or moisture haze as well as more dangerous impurities. The "Puri-Filter" is the ultimate in turbine or engine oil lubrication purification.

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DE LAVAL OIL PURIFIERS

for most dependable power production

PLUGS ARE OUT WITH CHLORINATION

Costly plug cleaning, with its high labor bills and lengthy equipment down-time, goes out of the condenser and heat exchange picture the minute chlorination arrives.

This proven process for cutting the costly effects of back pressure and poor heat transfer characteristics caused by slime, really works, as one Southern Power Station found out when they began using the W&T De-sliming Process. In just six months after W&T Chlorinators were installed, cleaning and excess steam costs were reduced from $1450 per month to $250 per month and a later survey showed an overall saving in excess steam costs of $16000 in a year.

Such savings are indicative of how your condensers may be made to operate more economically and with far less outage when W&T Engineers install chlorination to fight your slime problems.

To learn how chlorination may be profitably applied to your heat exchange equipment and to take advantage of W&T's 35 years' experience, write today.

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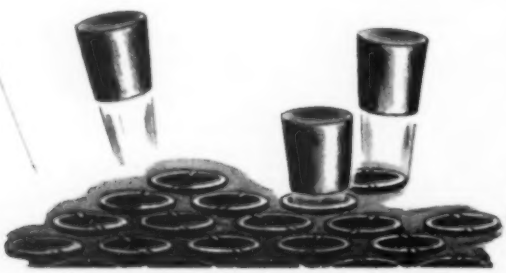

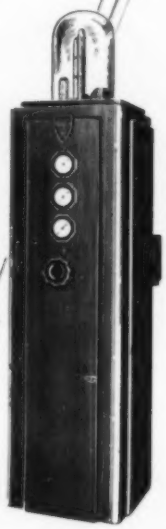

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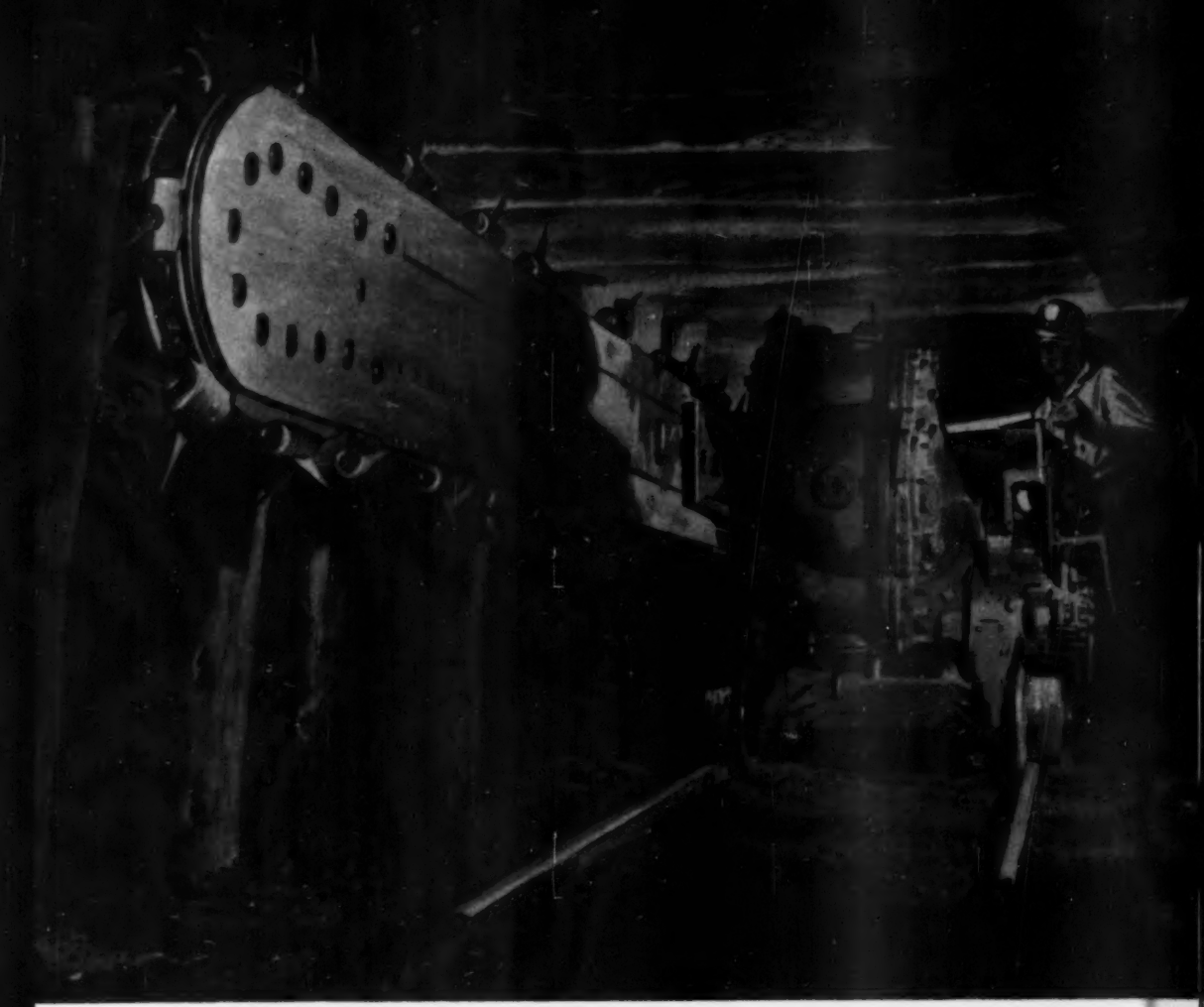

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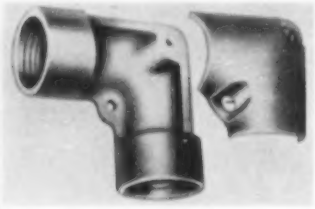
NEW EQUIPMENT NEWS

WHAT'S NEW? On these pages the Editors summarize the outstanding industrial developments of leading manufacturers who will supply you, free of charge, the bulletins or other information desired. For ease in making requests use the no-obligation, postage-paid card pages 35-36.

1—PULL-IN CORNER ELBOW

For running conduit around sharp corners without forcing the wires.

This pull-in corner elbow is said to make sharp right angle turns possible for straddling beams or for any location requiring a snug corner fit. Cover is removable and located on the side of the elbow to permit use on either inside or outside corners. Cover is large, and when removed, allows wires to be pulled in straight in either direction, company states, adding that this fitting is approved by Underwriters Laboratories. It is available in ½, ¾ and 1 in. sizes. Gedney Electric Co.



2—IMPULSE STEAM TRAP

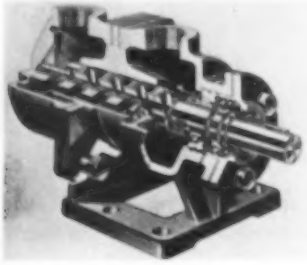
Is made with body of Type 416 stainless steel bar stock

A recent improvement in company's impulse steam trap for working pressures to 400 lb and temperatures to 450 F is the use of a stainless steel body to provide increased resistance to abrasion and corrosion encountered in severe steam trapping service. Internal parts, as before, are made of stainless alloys. Yarnall-Waring Co.

3—LOW COST PUMP

Is especially designed for standardized quantity production

The IMO Series A313A pump is for pumping petroleum products and other light or viscous fluids in volumes to 85 gpm against pressures to 150 psi, as required for rotary and steam atomizing oil burners, oil transfer, lubrication, hydraulic systems and similar service. Its reduced cost is expected to extend advantages of company's IMO principle to many applications requiring a reliable, quiet, pulsation-free high-speed pump.



Only working parts in the pump are its power rotor, and a pair of sealing or idler rotors. Pump can be direct-connected to electric motors, turbine or other high speed drivers. Because of its compact design, the A313A requires little space. All parts are interchangeable. Pump can be mounted in any position and suction can be located at top, bottom, horizontal left or right. De Laval Steam Turbine Co.

4—WATER CONDITIONER

Combines both hot process and zeolite softening methods

In this equipment the zeolite softener is used as a second stage following the first stage in which lime is the single reagent. The first stage precipitates the bicarbonate and magnesium in the water supply, company explains, leaving the remaining hardness to be removed by the zeolite softener, utilizing salt as a regenerant.

This combination of hot process and zeolite is credited to new high temperature resins used in the zeolite stage which are said to withstand both high temperatures and pH values obtained in the hot process stage. Advantages claimed include savings in chemicals and capital investment, lower CO_2 in steam, less floor space and head room required, better control of phosphate excess in boiler, lower alkalinity. This softener is recommended in treating turdid surface water high in carbonate hardness and silica. Cochrane Corp.

5—ELECTRICAL CONNECTOR

For use on hot lines, saves time in making branch connections

The Snaptrap is safe to use in connecting to hot lines, company states, and the connection is made without stripping main line insulation or exposing the copper. Snaptrap accommodates 350,000 to 800,000 circular mil cable—No. 14 to No. 6 branch wires. To use, just saddle it on the insulated cable, screw up the nuts on the U bolt and the connection is made. Connector has a split insulating block of high strength, high dielectric plastic. The clamping yoke is cadmium plated and the U bolt is bronze. Gemmer Mfg. Co.

6—RELIEF VALVE

Features out-of-the-water bellows assembly to forestall liming

The new Tempo Valve is described as a completely automatic reseating temperature and pressure relief valve. It is available in several types and specifications. A. W. Cash Valve Mfg. Co.

7—MINIATURE RECORDER

For pneumatic transmission of flow, liquid level, pressure, temperature

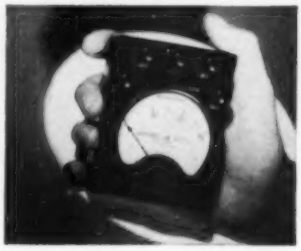
The Transet Recorder was designed to answer the need for a small recorder to provide processing data on the panel itself. It is said to be suited for either graphic or conventional panels and fits a panel opening of $3\frac{7}{8}$ by $4\frac{1}{2}$ in. with a flange measurement of $4\frac{3}{8}$ by 5 in. The door is clear plastic, when it is open, adjustments can be made for checking of valve position and automatic-manual service.

The Transet records transmitter output in terms of process variable measured. The 3-in. wide chart travels from right to left, 1 in. per hr, to produce a record similar to one which would be plotted by an engineer. Electrically driven chart mechanism is designed to pull out like a camera. The scale at right shows actual process range of transmitter and it is graduated 3 to 15 psi for noting valve position and checking calibration. Taylor Instrument Companies.

8—PORTABLE INSTRUMENTS

Use both moving iron and permanent magnet moving-coil mechanisms

The Type P-12 line includes single and multiple range models. Ammeters are available in full-scale ranges from 20 mu-a to 50 amp d-c, and from 5 ma to 50 amp a-c. For d-c voltages, full-scale ranges run from 10 mv to 800 v. Rectifier milliammeters come in full-scale ranges from 0.5 to 10 ma, and rectifier voltmeters from 2 v to 800 v. Outline dimensions of meter are $3\frac{7}{16}$ in. wide, $4\frac{1}{4}$ in. long and $1\frac{13}{16}$ in. deep for the d-c type—the a-c meter is $2\frac{7}{16}$ in. deep. All instruments are magnetically shielded to permit use of instruments on both magnetic and non-magnetic surfaces. Westinghouse Electric Corp.



9—DOUBLE UNION GAGE VALVES

Are made with union connection to both gage and tank or vessel

The design of these valves is intended to permit turning gage in any desired angle, or removing it without removing valves or draining liquid from vessel. Gage can be taken to work bench for servicing or replacement of gaskets or glasses. With valves in "closed" position gage may be removed by undoing union nuts on gage side, without draining or relieving pressure of the vessel, it is explained. These valves are said to lend themselves to substantial cost savings in applications as standard angle

How to simplify your piping jobs ...Standardize on the CRANE line

ECONOMICAL VALVES FOR LOW PRESSURES

Keep Crane 25-Pound Iron Body Double Disc Gates in mind for services that don't require the usual 125-Pound valves. Rated at 25 Pounds Steam or Gas, and up to 50 Pounds Water, depending on size, they give superior service in a wide variety of applications. Use them inside or out; their oval-shaped body and bonnet have ample reserve strength under line stresses. Short and compact, they take minimum space in pipe lines.

For durable, tight seating—yet easy opening—seat rings and disc faces are brass. Crane 2-piece ball-type gland maintains uniform pressure on packing; prevents binding on stem; lengthens packing life. When specified, these valves can be fitted with gears, by-pass, and clean-outs; also can be motor or cylinder operated; non-rising stem, flanged or hub ends, up to 36-in.; O.S. & Y. type with flanged ends only up to 48-in. See your No. 49 Crane Catalog.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
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No. 793½, Outside Screw and Yoke. Working Pressures: 25 pounds steam or gas; up to 50 pounds cold water. Sizes: 10 to 48-inch.

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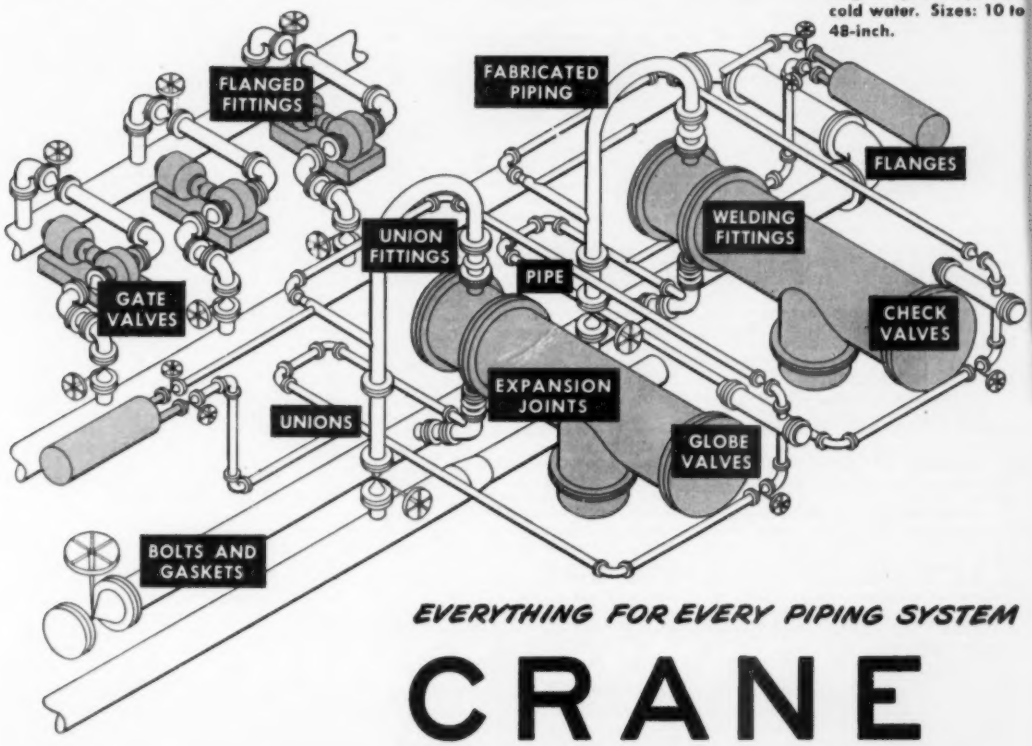

EVERYTHING FOR EVERY PIPING SYSTEM

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globe valves. Line also includes two offset valves and a steam-jacketed globe type. Jerguson Gage & Valve Co.

10—BOTTLE TILTER

Is engineered for safe pouring of liquids into smaller containers

The GS Tilter for 5 gal bottles is intended to prevent accidents caused by spilling, splashing and carelessness in pouring liquids. A chain is provided to hold bottle in position when tilted. Cradle is steel and all members are riveted or welded. Costs $6.25. General Scientific Equipment Co.

11—CENTRIFUGAL PUMPS

Cradle mounted, available in five sizes, single and two stage

These pumps, in sizes ranging from ¾ to 5 in. discharge with capacities to 1600 gpm and heads to 250 ft, have normal horsepower range from ¼ to 75 hp. They may be driven by direct electric motor, electric motor and V-belt, turbine through reduction gears, direct turbine, V-belt gasoline engine or direct gasoline engine. Impeller is company's latest hydraulic design. An extra deep stuffing box is provided to accommodate five or more packing rings. Ingersoll-Rand Co.

12—PRESSURE INSTRUMENT

For electronic measurement, recording of dynamic and static pressures

The Electro Pressuregraph, which has application in the maintenance of internal combustion engines, compressors, injection pumps, pipe lines, is designed to measure and record pressure variations in either gaseous or hydraulic media. Its versatility is credited to excellent frequency response and wide range, obtained through use of interchangeable diaphragms.

Equipment consists of electronic pick-up, an associated electronic circuit and power supply, and cathode-ray oscilloscope on whose screen the pressure-versus-time characteristic is presented. When used with Synchro-Marker, the instrument provides three information channels on same diagram: a pressure curve showing pressure being measured; a predetermined reference point that can be set at any angular position, and a choice of time or angular markers. Pressuregraph operates on a system of carrier modulation. Electro Products Laboratories, Inc.

13—ACCUMULATORS

Low-pressure-air operated, for storing fluids at up to 10,000 psi

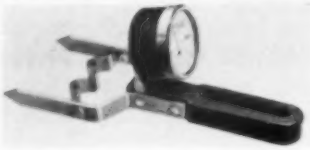
Ordinary plant air at 60 to 200 psi is used as compressible medium in these accumulators. In pump circuits, oil flows from pump into the accumulator during the non-demand pump cycle. The oil, under the high pump pressure, works against a hydraulic piston driving a larger air piston which, in turn, works against the low pressure compressible (air) medium. Oil is thus "stored" at pressures up to 10,000 psi.

All metal construction is provided to withstand shock loads. Units can be uploaded and reloaded at will, company points out, and can be used in non-pumping applications. Another feature claimed is that by changing circuit connections these units can be used as "boosters" with either plant oil or air line pressure as input medium. Units come in several sizes and mounting styles. Miller Motor Co.

14—BATTERY CELL TESTER

Is described as light, sturdy, easily used and conservatively priced

The King Model CC-3 Cell Tester has a 2½ in. meter calibrated to indicate



charge-discharge-dead as well as actual voltage. The temperature-compensated load of approximately 200 amp equals average engine starter load, thus providing an accurate battery test, company points out. Electric Heat Control Co.

15—STUFFING BOX

For orifice meters, is intended to reduce maintenance, leakage

This orifice meter stuffing box is designed to reduce maintenance at the pen shaft which transmits motion of meter's float, and lies between high-working zones in the manometer and atmospheric-pressure zones in chart case. Box is claimed leakproof at working pressures up to 5000 psi. Its heart is a combination packing and bearing machined from Teflon, and it is the waxy surface of this plastic (low coefficient of friction) and minute cold flow under pressure that are credited with solving high-pressure problems.

In this design a spring-loaded follower sleeve compresses the Teflon bearing in a gland and the Teflon acts as packing material and adjusts itself to stuffing box body and periphery of shaft. While this design doesn't require lubricant as a sealing medium, light oil or lubricant can be applied to shaft without harming its performance, company points out. Stuffing box body and component parts are stainless steel. Use of this box will be standard on company's Emco orifice meters for low and high pressure use. Pittsburgh Equitable Meter Div., Rockwell Mfg. Co.

16—ANALYTICAL INSTRUMENT

Measures and records phenomena convertible into electrical impulses

According to company, the possibilities of the Analascope can be appreciated from the fact that at one moment it can serve as a pH meter measuring to 0.001 pH, and the next moment as a pressure indicator, strain analyzer or instrument for measuring any function that can be translated into electrical impulses, whether static, fluctuating, or of high or low impedance.

Results are displayed on the long persistance screen of a 5 in. cathode-ray tube to permit continuous observation of non-recurrent phenomena at sweep speeds of from 0.01 to 5 sec. A two decade potentiometer calibrated with a self-contained standard cell is used to provide direct measurements from 0.001 pH to 15 pH and 0.1 mv to 1.5 v. An input attenuator of 1000 meg provides overlapping ranges of 1 mu-a to 10 ma and 1 mv to 100 v per centimeter deflection. Analytical Instruments Inc.

17—HOOK-ON WATTMETER

For active and reactive power measurements in single, polyphase circuits

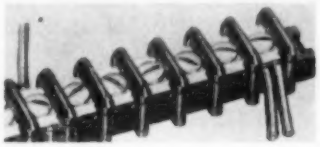
The Type AK-2 Wattmeter is designed to enable measurements to be taken without service interruption. It uses a removable magnetic hook to surround current carrying conductor, and potential leads are connected as in a conventional single-phase wattmeter. A three-phase balanced power measurement is possible with the hook-on unit, by passing two power leads through the hook.

A single dial switch makes possible selection of any one of six power measurement ranges to provide readings from 3 to 300 kw full scale deflection. Simple-switching, direct-reading scales of this wattmeter, introduced as companion unit to company's AK-1 Voltmeter, are claimed to result in one-hand operation with minimum possibility of error in use. Meter and Instrument Divs., General Electric Co.

18—THERMAL BLOCK

For use with small wires only, maximum of AWG 18 stranded and 16 solid

The Type E Terminal Block is designed so as to allow two wires to be securely clamped into position with positive contact. It merely requires loosening of one screw, inserting stripped wire between clamping members and retightening the screw, company states, and



tests are said to show that the wires will break before they can be pulled out of position.

Block body is molded of thermo-setting material and screws nest in a blind hole to eliminate danger of shorting to ground. Any number of terminals per block, up to 22, may be had from factory. Curtis Development & Mfg. Co.

19—A-C TIMING MOTORS

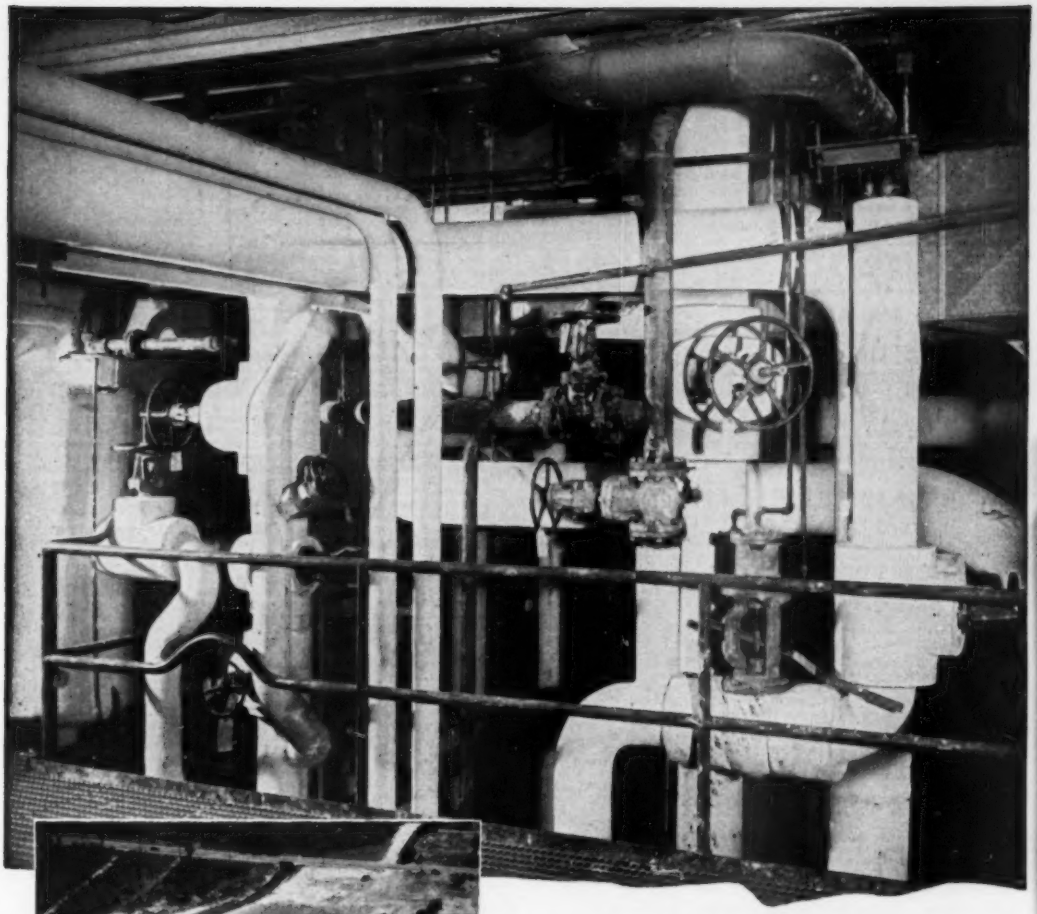
Are standardized units of the synchronous hysteresis type

Outstanding features claimed for these motors are high starting and running torque and quiet operation. They are designed to run at full synchronous speed over a wide range despite variations up to 25 per cent in line voltage, and to offer a considerable range of speeds and current ratings. Other features announced are slow speed rotor, shaded pole construction and long life. Motors fitting standard specifications are available from stock, or complete timers incorporating these motors can be designed for volume requirements. A. W. Haydon Co.

20—FLEXIBLE COUPLINGS

For engine drives, applications involving severe torque fluctuations

Features stressed for the re-designed Airflex Couplings are increased torque capacity credited to improvement in rubber composition and bonding, and hubs and adaptor plates engineered to facilitate disconnection and removal of entire gland assembly. New components are interchangeable with equivalent of company's couplings now in use and standard parts may be combined to allow six different mounting arrangements including flange mounting on a flywheel. Stiffness factors can be controlled and are available for torsional analysis, it is stated. The Falk Corp.



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CATALOG LIBRARY

This monthly list of the latest standard catalogs and bulletins is designed to aid the engineer in maintaining his permanent catalog file of engineering data. The items listed, unlike those under Helpful Bulletins, will appear each month except for additions and deletions determined by space requirements or by the manufacturers issuing the bulletins. Use the Helpful Bulletins coupon in requesting these copies.

BOILERS AND AUXILIARIES

201 **Working Pressure Data Card**—Maximum allowable working pressures for water tube and fire tube boilers are compiled in a handy reference table. Technical Data Card No. 113 A. It lists pressures in pounds per square inch for seamless and electric resistance welded carbon steel tubes or nipples for different diameters and gages of tubes conforming to ASME specifications. Chart is printed on firm stock, and punched for binding. The Babcock & Wilcox Tube Co.

202 **Dowtherm Vaporizer** — Bulletin No. 48-2, describing manufacturer's Type "A" Dowtherm Vaporizer tells how this unit is designed to evaporate Dowtherm in such a way as to provide dependable operation at maximum temperatures, discussing its construction advantages in detail. It is illustrated with photos of the vaporizer and includes a dimensional drawing, vaporizer chart and specifications. Also included is table showing general properties of Dowtherm "A." The Wickes Boiler Co.

203 **Tube Expanders**—Bulletin 380, 8 pp, covers manufacturer's line of tube expanders for maintenance of high pressure boiler tubes, superheaters, economizers, circulating tubes, steam generators and like equipment. Various models are illustrated by photo and described as to application. Also included are engineering drawings to show typical applications of one model. Thomas C. Wilson, Inc.

204 **Bent Tube Boiler Data**—this 20-pp booklet is filled with engineering drawings of recent installation of company's Class VL boilers, designed for adaptation to limited space conditions in plants having diverse steam requirements. Text covers main design features of these bent tube boilers. Henry Vogt Machine Co.

205 **Steam Generators** — Engineering data on manufacturer's coal, oil, gas or combination fired package units for generating steam up to 35,000 lb per hour is presented in Bulletin PG-49-13, 12 pp. Includes dimensional data and drawings, a discussion of design features and drawings illustrating firing arrangements. Foster Wheeler Corp.

VALVES, TRAPS, PIPING

206 **Piping Materials Catalog**—Corrosion resistant valves and piping materials are covered in illustrated circular No. 320, 32 pp. Contains information on manufacturer's complete line of valves, fittings, fabricated piping and pipe coils to meet a wide range of corrosive conditions. Listing includes both photos and cutaway drawings of models, complete specifications, sizes and prices. Includes a description of alloy metals used and a corrosion questionnaire. Also included are several pages of condensed recommendations on the selection of piping materials according to service requirements as well as a pictorial chart showing basic types of valves with names of their component parts. Crane Co.

207 **Valves Bulletin**—A new catalog section 12-H describes all types of the company's cast steel pressure-seal bonnet valves. Information on choosing the best size valve for your service is given in one page of the booklet under the title, "Correlation of Valve Size and Pressure Drop." Design and construction advantages of the valves are given and tables of pressure and temperature ratings. Details of design including operating mechanism, body design, disk piston, and other features are explained. Dimensional details are given in tabular form accompanied by dimensioned line drawings. A standard materials specification table is presented. Edward Valves, Inc.

208 **Control Equipment**—**General Catalog** 901, 20 pp, is devoted to measuring and control equipment for water and sewage works, power and processing industries. Catalog illustrates and describes in detail: venturi tubes and meters, controllers, gages, manometers, pitot equipment. Includes capacity tables, dimensional data, specifications, layout drawings. Simplex Valve and Meter Co.

209 **General Service Valves** — Bulletin E-160, 12 pp, describes and illustrates the design and construction of company's quick-operating valves, explaining their application to blow-off service and on fire protection, chemical process, soot blower, water column blow-down, and other types of pipe lines. Included are tables of dimensions, weights and list prices for straight lever and rack-and-pinion types, inside packed and with outside stuffing box and with screwed or flanged ends. Everlasting Valve Co.

210 **Unions and Fittings** — Twelve-pp Catalog 50 covers manufacturer's line of unions of all types, elbows, tees and fittings. It describes and illustrates special construction features and other advantages. Also illustrates all equipment offered, along with sizes, materials, current price list. E. M. Dart Mfg. Co.

211 **Strainers**—Bulletin S-202, 4-pp, describes and illustrates company's fine screen strainers for steam traps, reducing valves and other pipe line equipment. Tells why strainers are needed; discusses special features and construction details of these strainers. Includes pressure and screen data tables, suggestions for installing, and dimensions, weights and prices. Yarnall-Waring Co.

212 **Steam Traps and Temperature Controls**—Here is a comprehensive catalog comprising many of company's bulletins on steam traps and related equipment, including an illustrated steam trap chart for easy selection of the right trap for each application. Provides data on boiler steam traps, air eliminators, thermostatic steam traps and air vents, inverted bucket steam traps, temperature regulators and cooling controls, steam and water mixers, thermostats and strainers. Generously illustrated with photos, engineering drawings, catalog contains full dimensional and application information as well as list prices. Sarco Co., Inc.

213 **Steam, Air, Gasoline Traps** — This 32-pp illustrated catalog, No. 250, describes five types of thermostatic steam traps for pressures to 225 lb; expansion steam traps for pressures to 250 lb; weight-operated traps for steam, air and gasoline service, pressures to 1500 lb; piston-operated steam traps for pressures to 650 lb, and also steam, air and gas separators. Includes capacity tables, installation diagrams as well as a discussion of typical applications, and a section giving data, charts and formulas for determining proper size trap for specific applications. W. H. Nicholson & Co.

214 **Handbook on Fittings and Flanges** —Catalog wf-1950, 88 pp, is packed with working information on manufacturer's seamless carbon steel welding fittings and forged steel flanges. In addition to presenting standard schedules with their specifications, list prices and sizes, this book gives information on dimensional tolerances; American standard flange facings with dimensions; thread standards and threading practice; service pressure ratings, physical and chemical requirements for flanges, nuts and bolts; plus sizes and wall thicknesses of welding fittings stocked in other metals such as stainless steels, Inconel, pure nickel or Monel, aluminum, deoxidized red brass. Grinnell Co., Inc.

215 **Welding Fittings and Piping Manual** —In addition to data on company's line of welding fittings Catalog 48, 184 pp, contains a 65-pp technical reference section on welded piping systems. Book contains charts, tables, graphs, condensations and discussion of pipe specifications, welding data, design formulas, metallurgical information and other engineering data. There are digests of more than 20 ASA and ASTM specifications covering pipe, fittings and flanges, with a discussion of code requirements for pressure piping.

One section is devoted to tables on working pressures, stress values and pressure ratings, and charts are included for calculation of expansion, modulus of elasticity and flow resistance of bends, fittings and valves. Additional charts show working dimensions of fittings and flanges and over-all dimensions of combinations. More than 100 photos show types of installations and illustrate their use as welding saddles and sleeves. Catalog includes pictorial index. Midwest Piping & Supply Co., Inc.

HEATERS, HEATING

216 **Tubular Heat Exchangers**—**Bulletin** 916, 32 pp, describes present designs of the company's tubular heaters, coolers, condensers and heat exchangers and their distinctive features. The various types of shells, tube bundles, stationary heads and floating heads are fully explained, together with statements of the particular services for which each is suitable. An additional helpful feature of the bulletin are tables of the characteristics of tubing, the thermal resistance of tubes and pipes of many different metals and alloys, and the specific gravity and pounds per gallon corresponding to degrees Baume and API. Also presented are charts of specific heats of midcontinent crude oils and for solving MTD formula with correction factors for other than countercurrent conditions. The Griscom-Russell Co.

217 **Water Heaters**—Illustrated 6-pp Bulletin 70, Section I, on instantaneous type water heaters contains detailed capacity and dimension tables for two-pass, four-pass and six-pass designs, with tube bundles removable for inspection. A typical piping hook-up for installation of these heaters is shown. Also included are instructions for heater selection, engineering data to determine boiler capacities required for heating water, and a chart to determine pipe sizes for any steam flow at most pressures. Davis Engineering Corp.

218 **Condensate Drainage Control** — Manufacturer's system of high-pressure and high temperature condensate drainage control is fully explained in 24-pp Publication No. 3250. Contains useful data on steam flow conditions and heat exchange characteristics. Gives material and operating specifications and capacity ratings for both standard and high differential units in six sizes from 3 to 25 hp based on a maximum of 200 psi above process pressure. Differential pressures to 200 psi are listed and capacities for each unit tabulated for unit inlet pressures. Cochrane Corp.

219 **Combustion Catalysts**—Bulletin 36, 4 pp, explains the action of company's combustion catalysts, including one type developed for use in coal-fired furnaces and another for use in oil-fired furnaces. Tells how they help to remove soot, control smoke and alleviate the slagging problem in boiler furnaces. Also describes a simple hopper-type feeding device available for spraying the catalyst into coal-fired furnaces. National Aluminate Corp.

220 **Unit Heaters** — Illustrated Bulletin TH-2, 8 pp, covers a heater which is driven by a steam turbine, the exhaust from the turbine being piped into the heater section for heating the air. Complete details of the design and construction together with engineering data and dimensions both on the revolving discharge units and the fixed discharge units are included as well as a table on mounting heights and coverage. Piping details are also shown. L. J. Wing Mfg. Co.

221 **Heating Unit**—This bulletin presents advantages of company's gas- or oil-fired self-contained industrial heating unit, explaining its operation, simplicity of installation, and describing and illustrating some of its applications. Includes specifications. Also contains engineering data to help analyze industrial heating problems, including procedures to determine heat load, fuel consumption. Thermobloc Div., Prat-Daniel Corp.

WATER TREATING, CORROSION PREVENTION

222 **Water Conditioning Bulletin**—This is an eight-page discussion of water and chemicals developed for conditioning it to control scale and algae and inhibit corrosion. Describes several chemicals in detail, giving properties, composition and application. Also discusses special purpose chemicals. Wright Chemical Corp.

223 **Corrosion Analysis**—Excellent working data on galvanic corrosion is contained in this 8-pp technical study of corrosion by concentration cells, reprinted from Inco Corrosion Reporter, Vol. 3, No. 1. Discusses concentration cells, the metal-ion cell type, oxygen cell type, reversible concentration cells, their practical aspects and some rules for minimizing or preventing concentration cell corrosion. Illustrated with sketches showing conditions which accelerate corrosion. The International Nickel Co., Inc.

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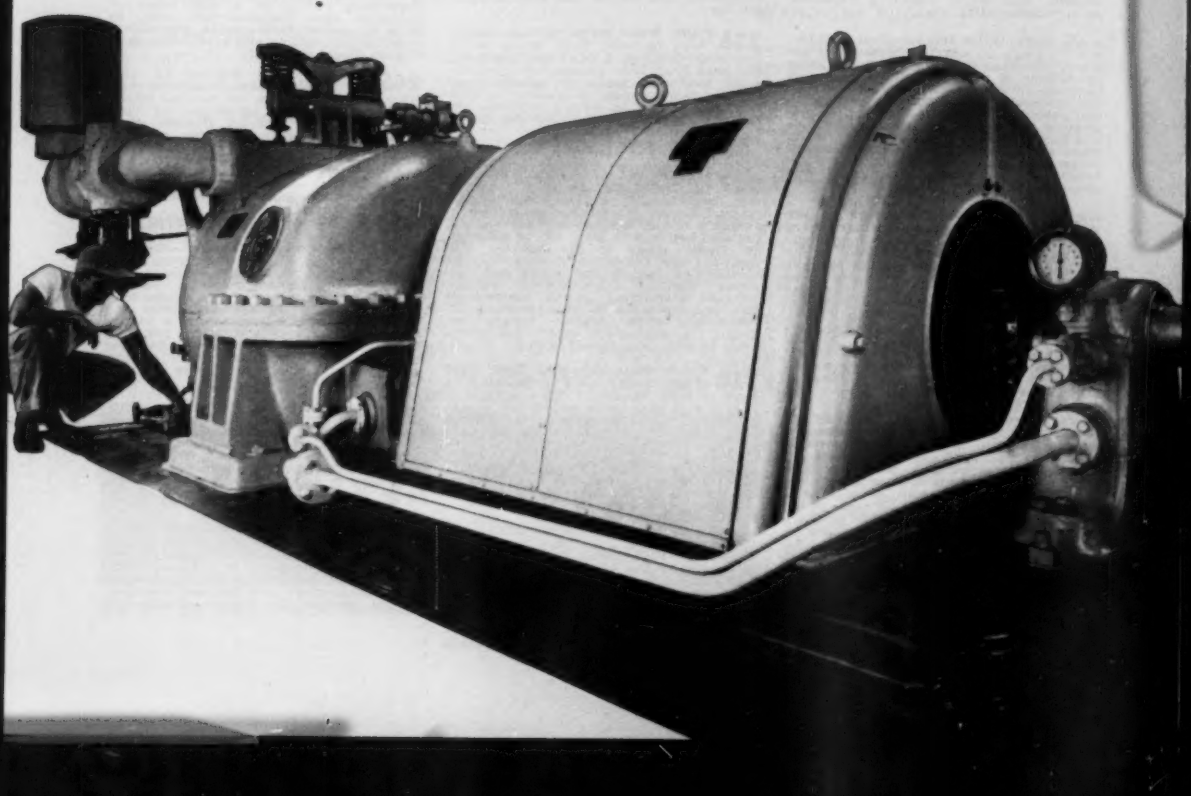

224 Corrosion Resistance of Nickel Alloys—Technical Bulletin T-3 contains 44-pp of illustrated information on the resistance of high nickel alloys to corrosion by sulfuric acid. Although technical in nature, it is written so as to be readily understood by non-technical staffs. Performance of 20 nickel-bearing materials in a wide range of service is discussed, and there are 16 tables and 33 graphs and photos. Problems involving a wide range of operations are covered. The International Nickel Co., Inc.

225 Cleaning Industrial Equipment—This is a general information bulletin on manufacturer's service for cleaning steam generating, heat exchange and other industrial equipment. Also included is information on pipe line cleaning and water well acidizing. Illustrations of these services are included, and bulletin treats in detail the methods used to remove incrustations from internal surfaces economically with minimum of downtime. Dowell Inc.

226 Anti-Foam Treatment — This 4-pp bulletin covers a new formula in powder form to be applied along with anti-scale treatment for improving steam quality, controlling scale in boiler feed system and sludge conditioning. It discusses the problem of steam contamination and explains the action of this polyamide anti-foam treatment. Tells how it should be applied and gives dosage requirements. A discussion of its advantages is accompanied by photos showing the effect of polyamide action on a boiling dilute Nacconol solution. Dearborn Chemical Co.

227 Boiler Corrosion—A 12 page article discussing the cause and prevention of corrosion in boiler systems is presented in Beta Technical Paper No. 111 titled "Corrosion: Its effect in Boiler Systems." The corrosive effects of oxygen, carbon dioxide, ammonia, hydrogen sulfide, acidity and physical factors are evaluated. Numerous illustrations, graphs and tables aid in understanding the article. W. H. & L. D. Beta.

228 Turbine Blade Deposit Study—Identification and prevention of steam turbine blade deposits and boiler water conditioning to prevent such deposits are discussed in the new 16-pp illustrated Bulletin 28B7030. Describes x-ray diffraction methods employed by the company for identification purposes and the results obtained. Tables list the partial chemical analyses of deposits containing sodium disilicate, occurence data on compounds found, composition of turbine deposits from turbines operating at various throttle pressures and temperatures, and comparison of compounds found in turbine blade deposits with boiler operating pressures. Allis-Chalmers Mfg. Co.

229 Boiler Water Manual—Factual information on standard methods of applying chemicals in the treatment of water for boilers is presented in this 16-page technical bulletin, called Standard Method 122. Discusses pretreatment of raw water, application of chemical feeding to pretreating operations and both constant rate and flow responsive feeding direct to boiler drum and to feedwater systems. Also discusses condensate returns, flushing periods, condenser cooling water treatment and chemical tanks. Proportioneers, Inc.

230 Water Softener Equipment — How the problems caused by hard water can be offset by the use of water softeners is explained in Bulletin 2386, 12 pp, describing ion exchange equipment. It covers in detail downflow, upflow and gravity zeolite water softeners. Contains a 2-pp cutaway illustration of a fully automatic softener to show how an ion exchanger is built and how it works. Bulletin also contains flow diagrams showing arrangements for installation of water softeners and includes detailed, illustrated discussion of multiport valves used in them. The Permutit Co.

231 Corrosion Treatment — "Corrosion Protection of Steam and Condensate Return Systems" is a 4-pp folder covering a recently developed amine treatment for inhibiting of boiler and condensate systems. This treatment is described as affording surface protection of the metal itself as well as raising the pH value of the condensate. Booklet gives specific case histories and typical economies obtained by power plants using this treatment. Includes graphs showing relationship between free CO_2, pH and alkalinity in water, and the solubility of oxygen in water when exposed to air at various pressures. The Bird-Archer Co.

**232 Chemical Feed Systems — Single, complete "packaged" units for feeding directly into boiler feed water lines are the subject of 4-pp Bulletin 4811. It discusses in detail sodium sulfite feeding, internal treatment, chemical feeding, manual control, intermittent feeding of internal treating chemicals; automatic feed systems; automatic pH control, and automatic control by conductivity. Illustrations include photos and diagrams of controlled volume pumps. Milton Roy Co.

233 Modern pH and Chlorine Control —The new ninth edition of this 100-pp illustrated 6 by 9 in. paper-bound booklet has been revised to conform with the latest developments and most modern practice in water treatment. But it is much more than a catalog, although it does give full technical details of all the color comparators and equipment in water testing and control of boiler and industrial process water manufactured by this company. Its most important feature, however, is inclusion of much good technical information on the meaning of pH control, electrometric and colorimetric methods of determining pH and also determining constituent impurities in water; applications of water control in air conditioning; treatment of boiler feed water and industrial water, and other industrial applications. Descriptions of color comparators are detailed and illustrated, with the prices listed; and include a new testing set for total hardness of water. W. A. Taylor & Co.

234 Water Softeners—Bulletin WC-102 is a 36-pp presentation of recent developments in hot-process water softeners. Explains boiler plant troubles caused by various impurities in water, outlines 12 methods of treating water to eliminate these impurities, describes reasons for the popularity of the hot-process method and its advantages, and explains the chemistry of hot-process water softening. The two basic designs and operation of company's hot process softeners are described, together with six adaptations of each design to various plant conditions, such as per cent make-up, treatment of condensate, deaeration. Methods of supplementary hot phosphate treatment are also discussed. Includes more than 30 diagrams of hot process designs and flow charts, together with photographs of installations. Graver Water Conditioning Co.

235 Boiler Water Treatment — Bulletin 47, 8 pp, is on internal treatment of boiler water. Defines internal treatment and tells its advantages in softening, sludge conditioning, stabilization. Explains operation of company's system, including the chemicals used, feeding and testing equipment, and service. National Aluminate Corp.

236 Plant Wide Water Service—Titled, "Let's Consider Your Whole Water Problem," this 4-pp booklet analyzes water problems from four standpoints—procurement, treatment, usage and disposal—and explains how company is prepared to offer technical service in solving problems related to all four. Hall Laboratories, Inc.

ELECTRICAL

237 Synchronous Generators—This Bulletin, 05B6139A, describes construction features and electrical characteristics of engine-type synchronous generators in standard ratings from 25 to 10,000 kva and for standard speeds from 100 to 600 rpm, for Diesel, steam or gas engines. Also describes and illustrates mechanical construction of stators and rotors and discusses machine characteristics, ratings, voltages, frequencies, phases, temperature rises and operation at high elevation. Illustrations show typical installations. Control accessories are listed. Allis-Chalmers Manufacturing Co.

238 Synchronous Motors — High speed synchronous motors are described in 4-pp bulletin PB 5600-1. The bulletin is packed with descriptive matter and photographs explaining features of the motors rotor and stator. Mechanical modifications also are illustrated. Elliott Co.

239 Time to Retire Your Watthour Meters?—To aid power engineers in determining the economic point at which to retire older watthour meters, Bulletin GEA-5448, 12 pp, offers direct suggestions and includes an evaluator for making the job easy. The evaluator—a plastic circular slide-chart with scales showing cost of new meters, age of old meters etc.—is based on an economic formula developed by company engineers and explained in the bulletin. Use of this formula and the evaluator will assist in setting up planned retirement programs. Comparison of cost of retiring and keeping in service old meters, as determined by the evaluator, answers the question, "When is it economy-wise to retire a group of meters?" General Electric Co.

240 Care of A-C Rotating Equipment—To promote intelligent and consistent maintenance of electrical machines, company has published Bulletin 05R7417, which is a series of articles by Fraser Jeffrey. Contents of the 24-pp booklet cover preventive maintenance and machine repairs, and include such subjects as drying moist insulation, measuring insulation resistance, bearing clearances and proper machine applications. Machine repair chapters include data on stator coil and slip ring rotor repairs, balancing of rotating equipment. Allis-Chalmers Mfg. Co.

PUMPS, COMPRESSORS, ENGINES

241 Condensers—Bulletin 441-C, 28-pp, covers in detail every phase of manufacturer's line of condensers—their simplicity of design, accessibility, construction features. Illustrated with photos and drawings showing complete assemblies, parts, principles of operation. Bulletin also discusses emergency replacements, service and maintenance facilities available, and auxiliary equipment. Includes condenser tube data, pressure-conversion tables. Condenser Service & Engineering Co.

242 Compressor Selection Chart—Here's a new selection chart, based on normal applications handling air with atmospheric intake pressure. It simplifies selection of proper size compressor for average industrial use, with quick comparison between discharge pressure pounds per square inch gage and piston displacement cubic feet per minute and shows recommended compressor bore and stroke in inches. Chart covers two letter-size pages. Worthington Pump and Machinery Corp.

243 Air Compressor Lubrication Manual —Valuable information on air compressor maintenance is contained in this 40-page book on the lubrication of air compressors, second edition. Subjects treated include compressed air, compressors and related equipment, lubricating systems, compressor oils and their applications, lubrication requirements operating hints, oil requirements, storage and care of compressor oils, and safety precautions. All discussions are illustrated. Cities Service Oil Co. (In the South, Arkansas Fuel Oil Co.)

244 Steam Pumps — This is manufacturer's collection of bulletins covering all types of centrifugal and reciprocating pumps for a wide range of industrial uses. Contains more than 80 pp in all and includes photos, dimensions, specifications, ratings and application data. Warren Steam Pump Co.

245 Modern Steam Engines—In presenting steam engines as more than "just drives," Bulletin 306 touches briefly upon some of the advantages of "by-product" power. Bulletin features company's vertical steam engines of both throttling and automatic governor types. Sectional drawings are accompanied by engineering data, an illustrated discussion of construction features and photos of installations. Troy Engine & Machine Co.

INSTRUMENTS AND CONTROLS

246 Smoke Density Recorder — Bulletin 211, 4 pp, tells how company's bolometer-type smoke density recorder promotes efficient furnace operation and how it helps in the battle against smoke nuisance. It describes and illustrates the smoke detector which consists of a bolometer receiving and measuring radiation from a sealed beam light source. Recorder specifications, installation requirements, and measuring circuit details are also discussed. Bailey Meter Co.

247 Boiler Water Level Control — Bulletin 487 describes completely the installation of boiler water level control equipment at the Blackhawk Generating Station, Wisconsin Power & Light Company. Photographs of the installation are presented as is a schematic layout of the entire station along with tabulated significant data. Northern Equipment Co.

248 Recording Instrument Data Book—An oxygen-analyzer, based on the para-magnetic property of oxygen, is described and illustrated in Bulletin 49-829, 16 pp. Tells advantages and applications of the instrument; also discusses manufacturer's analyzer for carbon dioxide and

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Unretouched photograph showing encrustation of turbine blade section.

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other gases and an electronic recorder (temperature and pressure) for use with analyzers. Describes several recommended gas sampling systems. The Hays Corp.

249 Purity Indicator—An instrument for measuring and indicating electrical conductance of steam and water is described and illustrated in 6-pp Bulletin 11-21-46 RCU. It discusses problems encountered with steam and condensate purity and cites examples of how controller and alarm assembly are utilized in detecting and signalling impurities caused by carry-over and condenser leakage. Includes prices. E. F. Drew & Co., Inc.

250 Flow Meters—Illustrated Bulletin M-51, 4 pp, explains how automatic compensation for pressure or temperature variations, or both, are achieved in flow measurement of gases or liquids with company's compensated meters. A schematic diagram shows how a corrected record is automatically and continuously produced, with the chart also showing uncorrected flow. Another diagram illustrates installation of a pressure and temperature compensated flow meter, and photos show the meters equipped for compensating functions. Hagan Corp.

251 For Practical Men—That's the title of this 24-pp pocket-size booklet presenting insulation testing in simple language. Packed with maintenance hints, it explains electrical insulation, tells how it can be tested and what makes it go bad. It describes the Megger insulation tester and justifies its cost in terms of long run economy and prevention of shutdowns. Discusses the Megger as a trouble-shooter, pointing out its functions and telling how to get the most out of it. There's also a chapter on handling wet equipment. Photos, line drawings and humorous sketches accompany the text. James G. Biddle Co.

252 Flow Meters—Bulletin 400-F2, 8 pp, features company's meter for measurement of steam, air, or gas flow in 1 or 1½ in. pipe lines, and designed for installation directly in the line being metered. Illustrated with photos of meter, sectional and dimensional drawings, the bulletin explains how meter operates and discusses its advantages. Gives typical specifications and includes correction factor charts and capacity tables. Builders-Providence, Inc.

COAL HANDLING

253 Coal Scale Data Book—The answers to a power engineer's questions on coal scales are provided in this excellent 48-pp book, Bulletin 1143, covering scales for recording weight of coal consumed by individual boilers and weight of coal receipts from ship, car, truck or storage. It is generously illustrated with photographs of models and accessories and actual plant installations and contains all necessary engineering drawings, dimensional data and detailed specifications. Construction features and operation of weighing and feeding systems are described. Richardson Scale Co.

254 Spreader Stokers—Catalog 80, 44 pp, describes a spreader stoker with forward moving grate that slowly and continuously discharges ash at the front. Explains the efficiency and economy of this stoker, illustrating grate's design and operation. Includes discussion of typical power plant installations of these stokers, covering more than 30 industrial, institutional, municipal and public utility installations through the country. These are illustrated by photos and blueprint drawings. Detroit Stoker Co.

255 Coal Handling Equipment—Modern equipment for the storage and handling of coal and ash is presented in 24-pp Bulletin 300. Illustrated with sketches and photos of actual installations, it covers concrete and tile silos, cylindrical steel tanks, and suspended steel bunkers with gravity discharge bucket elevators and pivoted bucket carriers. Gifford-Wood Co.

256 Spreader Stoker—Bulletin SR 31, 4 pp, explains and illustrates, by photos, the design and construction features of company's spreader stokers, stressing their advantages. Also contains photos of installations. Erie City Iron Works.

257 Small Crushers—"For Better Testing and Small Scale Reduction" is the title of this 6-pp bulletin describing in detail the many practical applications of company's small crushers, grinders, and shredders for the reduction of coal, by-products, chemicals, clays and many other products. Typical installations are clearly diagrammed and explained. Special attention is devoted to construction features and functional advantages of the different mills as applied to various reduction jobs. American Pulverizer Co.

TURBINES

258 Turbine Catalog Collection—This is a valuable collection of bulletins in loose-leaf form. They cover a complete description of manufacturer's solid wheel turbines and feature cross section drawings of typical units for both moderate and high steam pressure conditions. Also provides a description of an axial flow impulse, both single and multi-stage, and complete data on speed increasing and speed reduction gears. The Terry Steam Turbine Co.

259 Velocity Stage Turbines—Catalog 62-19R, 8 pp, features turbines for mechanical drives designed to operate under all inlet steam conditions up to 600 psig and 750 F. Gives complete specifications, dimensions and includes chart showing how to estimate turbine sizes. Illustrations include cutaway view, photos of parts, speed governor and regulating valve, and emergency governor and trip valve are described. De Laval Steam Turbine Co.

260 The Answers on Turbine Oil—This 2-pp booklet answers several questions power engineers ask about turbine oils, including: What causes deposits of sludge? What causes acidity increase? What causes corrosion in turbines? Explanations are brief but thorough. Booklet is illustrated with photos of turbine installations in which manufacturer's products have been used successfully. Standard Oil Co. (Indiana).

DUST COLLECTING

261 Fly Ash Elimination—Power engineers will find this 30-pp booklet outstanding among material on this subject. It presents manufacturer's "Multiclone" equipment (described as small-tube type of cyclonic dust collectors using centrifugal force for separating dust from gas stream) as a highly successful and economical means of separating fly ash—not as a panacea for all cinder and fly ash problems. Parts and assemblies are illustrated by photos and drawings and explained in terms of construction, operation and capacities. Particle size and its significance in fly ash elimination, is discussed in detail and so is dust collecting efficiency as affected by operating conditions. Book also contains excellent engineering data on both single and double hopper installations. Western Precipitation Corp.

262 Dust Collectors—Dust collecting equipment for power plants, foundries, cement plants and similar industries is the subject of Bulletin No. 1428, 24 pp. Contains many photographs of installations, also photos showing equipment being tested in company laboratories. Discusses services offered by manufacturer in analyzing individual installation requirements. American Blower Corp.

FUELS, LUBRICANTS

263 Steam Power Plant Auxiliaries—In Vol. 36, No. 4, of Lubrication, a technical publication on selection and use of lubricants, is an article of recommended lubrication practices for steam power plant auxiliaries. Illustrated with photos and sketches, it discusses automatic coal firing machinery, stoker design, pulverizers, tube cleaners, compressors, motors, fans and blowers, external reciprocating elements of pumps and compressors and similar subjects. The Texas Co.

264 Diesels, Their Fuels and Lubricants—This 46-pp book offers a well organized and attractive presentation of practical information on Diesel engines, covering their history and economics as well as discussing their design characteristics and operating principles. Classification of Diesels according to speed is explained. Other chapters cover injection systems, combustion chambers, lubricating systems, and Diesel oil purification and filtration. The balance of the book is devoted to a discussion of fuel and lubricating oil required by Diesels and description of company's products. Book is filled with photos, sectional illustrations and schematic drawings and includes table showing relation of engine performance characteristics to fuel properties. Sinclair Refining Co.

OTHER EQUIPMENT

265 Pump Packings—Packings for use on reciprocating and centrifugal pumps are illustrated by photo and described in this 4-pp folder. It covers packings for practically all services and includes a table of recommendations to facilitate selecting the right packing for any particular application. Johns-Manville.

266 Concrete Floors Q & A—A new booklet titled Lumnite Concrete Floors—Corrosion Resistant and Heat Resistant, has just been published. The detailed information contained in this booklet brings up to date, the service experiences and late developments in this field. The information covers methods and materials used in placing corrosion resistant concrete in a wide variety of industrial applications. Typical uses of corrosion resistant concrete are listed for many industries and also given, are the answers to a number of questions often asked about it. Lumnite Division, Universal Atlas Cement Co.

267 Purger Bulletin—How air and other non-condensables get into refrigeration systems; the adverse effect of this on operating costs and efficiency and what manufacturer's forged steel purger does to prevent it are covered in 8-pp Bulletin 192. Also included are installation data with illustrations and diagrams, specifications and prices, helpful charts and tables. Armstrong Machine Works.

268 Welding Fittings and Flanges—Titled "Catalog and Engineering Data Book 211," this handsomely bound 262-pp manual provides complete dimensional data, weights and prices on company's welding fittings and flanges. The engineering section contains practical, illustrated information covering welding fittings and flanges under varying conditions of temperature and pressure, location and materials processed. Discusses their use in different piping systems.

A section is devoted to welding fittings and flanges in special metals and alloys and their specific applications. The technical section covers properties of pipe, rating of pipe, fittings and flanges, line expansion and flexibility, support and anchorage of piping and flow of fluids.

Distribution of this excellent piece of industrial literature is limited to major users, designers and erectors of industrial piping. (Please include your title when requesting it.) Tube Turns, Inc.

269 Transmission Belting—Catalog M-9922, 28 pp, gives detailed design, engineering and performance data on manufacturer's line of transmission belting. Tables on belt speeds, arc of contact, friction, horsepower correction, and service factors are included in the manual, together with hints on proper selection of a belt and procedure for analyzing belt drives. Illustrations include many photos of belt installations and drawings of transmission drives. United States Rubber Co.

270 Steels for Hot Spots—This is an 88-pp manual filled with information on steels for elevated temperature service. Includes a discussion of the general principles of high temperature behavior of ferrous materials and the factors influencing their behavior; a data section replete with tabular and graphical material covering mechanical property values of 21 steels; and illustrated description of major high temperature testing facilities in the United States, and a comprehensive bibliography of company's technical publications on the properties and use of steel at high temperatures. United States Steel.

271 Technical Data on Plexiglas—This is a file folder of technical and application information on Plexiglas sheets, rods and molding powders, covering their workability, physical properties, available thicknesses. Includes data sheets on the uses and advantages of Plexiglas in large area lighting, typical designs of coffers, photos of installation and a discussion of room lighting. Rohm & Haas Co.

272 Wired Television—Illustrated Bulletin 1025, 16 pp, introduces company's Utiliscope, a camera and monitor type of equipment designed to enable an observer to see where he can't look. Some of the many applications for this wired television which are described and illustrated include viewing instrument readings at remote points, checking boiler water levels, watching coal flow in chutes, watching hazardous laboratory tests, checking furnace ignition. Diamond Power Specialty Corp.

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Wherever you use float valves, avoid losing any of your operating force in the stuffing box. Insist on low and constant valve stem friction.

Make sure of instant, accurate response to your actuating force—no matter what your flows and pressures—by demanding close control of the unbalanced forces found in every valve.

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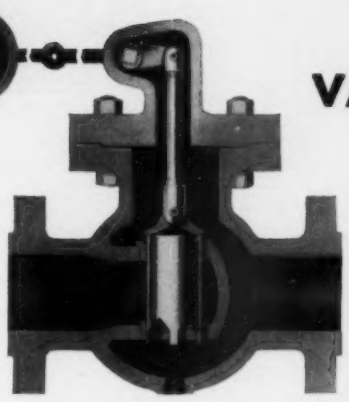
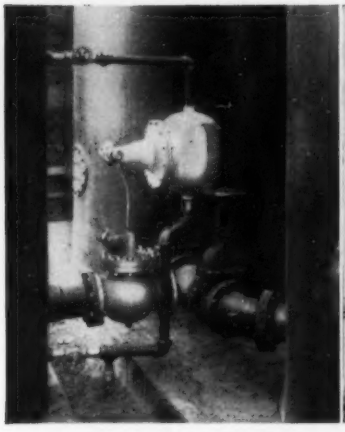
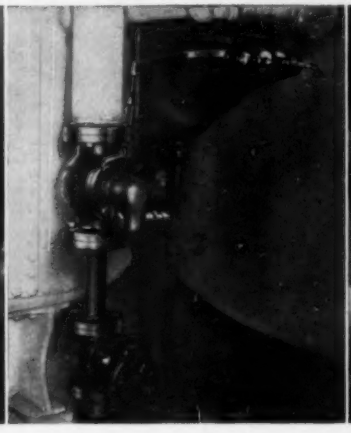
In other words—insist on COPES Balanced Valves. They offer all these important advantages —plus long service life with minimum maintenance. Write in detail about your needs.



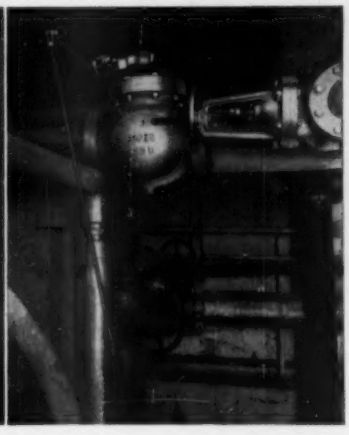
With the COPES Type BI Valve, rotating stem means low stuffing box friction. Accurate balance assures quick and accurate response. Exact capacity you need is provided.



Float-operated COPES Type BI Valve controls flow of condensate from flash tank to storage tank.



Flow of blow-down water from a flash tank is controlled by this float-operated COPES Valve.



Water level in a deaerating heater is controlled by this float-operated COPES Balanced Valve.

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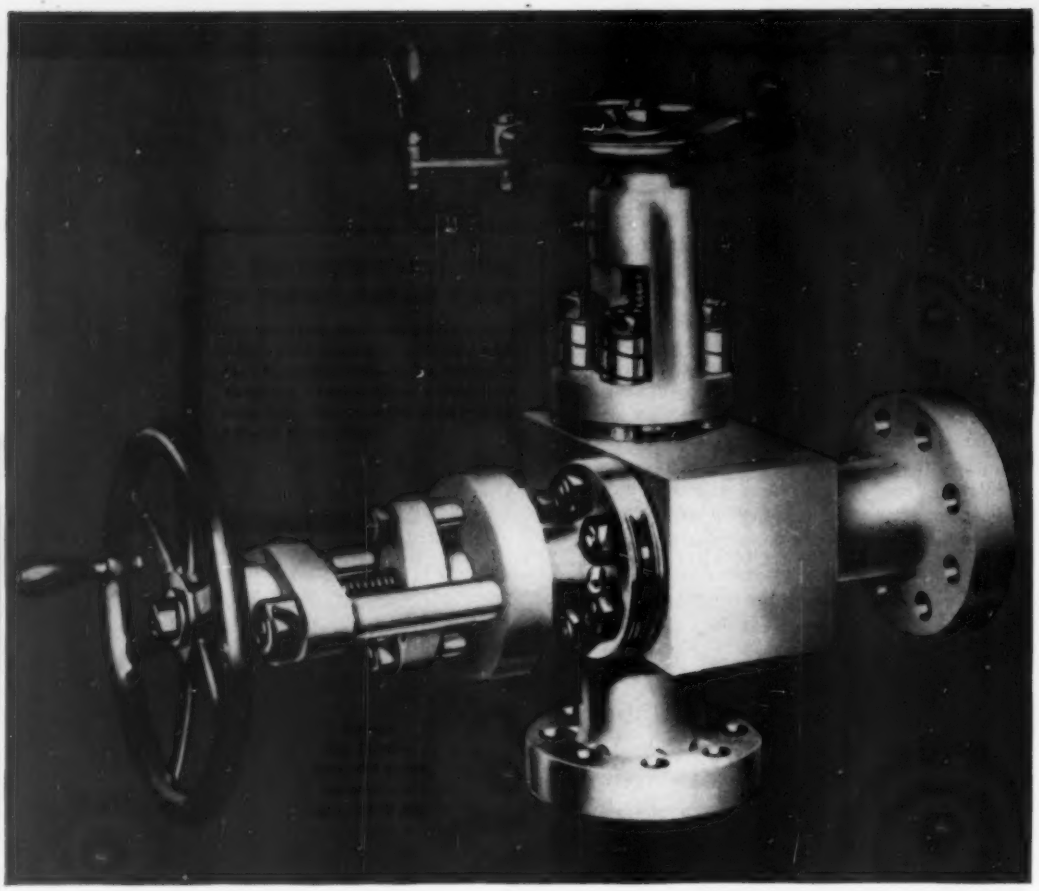

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The Yarway Unit Tandem Blow-Off Valve meets the most demanding requirements for boiler blow-down or drain service.

It's drop-tight—and rugged enough to withstand the severe punishment of regular or emergency blow-down under pressure, or periodic acid wash.

Two Yarway Stellite-Seat Hard-Seat Valves or a Hard-Seat (blowing) and Seatless (sealing) Valve are combined in a one-piece forged-steel body. Designed for pressures up to 2500 psi.

It is significant that more than 4 out of 5 high pressure boiler plants use Yarway Blow-Off Valves.

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YARWAY **BLOW-OFF VALVES**

LETTERS TO THE EDITORS

RIGHT TRACK

THE MAY 1950 issue of POWER ENGINEERING just arrived. By changing the title from *Power Generation* to POWER ENGINEERING you have clarified the scope of the magazine.

The articles you have been publishing for many years tell not only about generation of power, by all types of prime movers, but also cover construction, installation, methods of operation and maintenance of all types of plants and equipment used in generation, distribution and application of the power services.

You have been on the right track in magazine content and now you are on the right track in magazine title. Congratulations!

Barrington, Ill. JOHN H. D. BLANKE

HE'S GUILTY, HE SAYS

IN THE COMFORTABLE seclusion of the drafting room, with a mint julep on my left and a sun lamp on my right and a soft foam rubber pad supporting my copious posterior, I carefully ponder the profound wisdom exuded from the pages of your magazine in the form of an article eulogizing the Practical Engineer.

I am guilty! Yes, I plead guilty to the charges of garbling power plant geographies and making the lot of the Practical Engineer a well nigh unbearable one. I furthermore plead guilty to putting that valve symbol in a location governed by either an economy-minded purchaser, specific limitations imposed by manufacturer's specifications, clearance factors, supports of valves and piping, and the bad habit of following the instructions of my project engineer. So help me, if I had my way, I'd put the blasted thing right into Mr. Practical Engineer's lap.

Along with the 150 other scoundrels who call themselves draftsmen and poison the atmosphere of this secluded paradise called a drafting room, I again plead guilty. I am guilty of allowing my work to be scrutinized by engineers, chief draftsmen, checkers, purchasers, and operators. I humbly allow myself to be swayed by their unquestionable wisdom and authority. I put the symbol here, I put it there; I take it out, I put it back in; I make it motor operated, then hand operated and it comes to its final resting place where Mr. Practical Engineer can't get his hot, eager little hand on it. Surely Mr. Practical Engineer is not in favor of voiding the laws of expansion, upsetting practices of good flow and flexibility of piping systems, and playing hell in general with the power plant just to keep a couple of valves within his grasp.

Last, but not least, I must confess that I did toy with the idea of installing an access platform for valve accessibility, but allowed myself to be discouraged from this bit of strategy by Mr. Practical Engineer's boss, who pays the bills.

Please accept my apologies for I must move the sun lamp over to the other side.

FRANZ J. ROSENSTEIN

MOTOR IDENTIFICATION

THE PHARMACEUTICAL manufacturing plant at which I am electrical engineer contains quite a number of processing buildings. The processing equipment within each building may consist of kettles, centrifuges, blowers, pumps, filter presses, exhaust blowers, etc., upon which are located electric motors.

For proper and efficient maintenance of these electric motors it is necessary to establish a motor index file and draw up building wiring diagrams which show both the physical and circuit locations of the motors.

In order to refer to any of the motors in a building from the index file or the wiring diagrams, some convenient means of identifying the motors is necessary.

To find this means is my problem.

One consideration might be to use the nameplates already on the motors.

Experience at the plant has shown that whenever a motor had to be identified from its nameplate, it was almost always necessary to climb over pipes and girders, or crawl around equipment, or stand on one's head, or do all three, in order to read the nameplate.

As far as I am concerned, the nameplate is of little value as a convenient means of identifying a motor.

Another consideration might be to use a small elliptical-shaped brass tag, stamped with an equipment number and riveted to the motor frame.

Such a tag is used at the plant. Although it serves its purpose for inventory taking, it has the same disadvantages of a nameplate for quick and easy motor identification.

Therefore, it seems to me that the identifying means must consist of a code system and a medium to bear the code, and must be selected with the following requirements in mind:

1. Identification code of a specific motor to remain the same regardless of motor location change.

2. Motor to be identified from an on-the-floor vantage point.

3. Code and medium for bearing the code to be as compact as feasible.

4. Medium to be corrosion resistant.

5. Medium to be as tamper-proof as practicable.

I should greatly appreciate any information or suggestions from you or readers of *Power Engineering* which would help me find a satisfactory motor identifying means.

Rensselaer N. Y.

S. R. SHORTRIDGE
Electrical Engineer
Winthrop-Stearns Inc.

MIAMI-FORT STATION

THE ARTICLE on the Miami-Fort Generating Station of the Cincinnati Gas & Electric Co. in the May issue described a very interesting power plant but there are several points which I found somewhat difficult to understand. In fact, in reading the article, I found it necessary to imagine myself as the designer of this plant and then decide what I would have done in the same situation.

The two paragraphs on "The feedwater cycle" for example are particularly difficult to follow and in my opinion, the Design Performance Diagram of Unit 5 could be more complete.

In the first of the two paragraphs of this description of the feedwater cycle, No. 4 and No. 3 heaters have evidently been interchanged by error. In the second paragraph, the operation of the make-up and draw-off operation is not clear, and there seems to be confusion in the references to the hot-water storage tank, the miscellaneous drains tank, and the condensate storage tank.

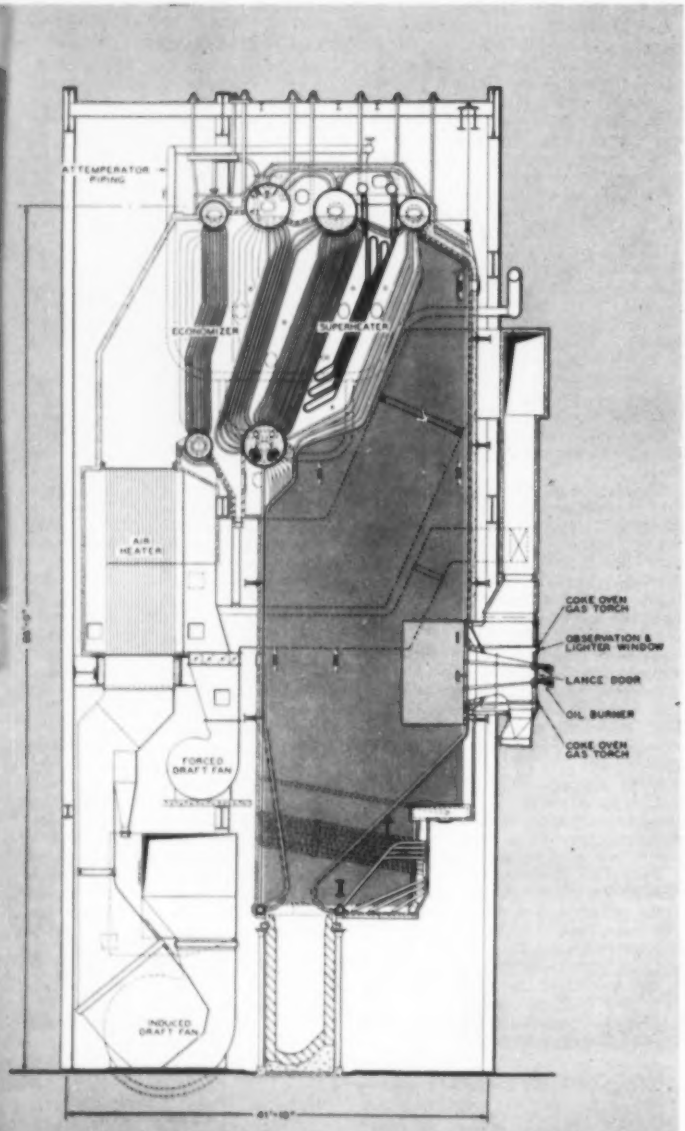
In the system I am associated with there is a make-up and draw-off tank adjacent to the condenser. There are four liquid level controllers on the deaerator storage tank. When normal high water level is exceeded one control opens a valve on the condensate pump discharge line which causes it to discharge to the make-up and draw-off tank. When the normal low water level in the storage tank is reached, a second control opens a valve on a line from the make-up tank to the condenser. When extreme high-water level is reached in the storage tank, a third control opens a dump valve on a line from the storage tank direct to the make-up tank. When extreme low water is reached, a fourth control valve opens on the lines leading directly from the make-up tank to the suctions of both the booster and boiler feed pumps.

There is also a large condensate

(Continued on page 111)

Power Engineering's FEATURE OF THE MONTH

Youngstown's New Boiler No. 7 Fired by Blast-Furnace Gas



WHEN THE Youngstown Sheet and Tube Co., at its Campbell Works in Youngstown, Ohio, put into operation a new power plant in 1928, that plant attracted a great deal of attention not only in the steel industry but throughout the power industry because of its outstanding features.

For one thing, it contained six boiler units, of a design modern for that time, replacing a total of 85 old boilers throughout the steel plant. Those six boilers were fired by blast furnace gas, supplemented by pulverized coal, the two fuels being controlled by an automatic control system that automatically supplied the pulverized coal to supplement deficiencies in the blast-furnace gas supply in order to maintain steam output. This control system alone was an outstanding development at that time; and, while it would not be considered so today, many of the things learned with that system have since become common practice in multi-fuel control.

Reference 1, page 121 gives details of boilers, turbine generators, turbo blowers, condensers, heaters, evaporators and other equipment installed at the Campbell Works power plant in 1928.

Added Steam Capacity Needed

The 1928 Campbell Works power plant continued to serve the steel mill adequately throughout the 30's and 40's, being improved as required and well maintained. But its capacity and equipment were taxed to the limit during the war and it became apparent that a new steam generating unit, at least, would be desirable to take the load and relieve con-

Fig. 1. General cross-section through new steam generating unit No. 7 at Campbell Works boiler plant, Youngstown Sheet and Tube Co., showing arrangement of fans, burners, air ducts, furnace. Unit burns blast furnace gas as primary fuel to generate 350,000 lb of steam per hr continuously at 400 psig, 700 F. Attemperator for steam temperature control in bottom drum

New 350,000-lb-per-hr, 400-psig, 700-F steam-generating unit designed to burn wet, washed blast-furnace gas as primary fuel, added to existing boiler plant at Campbell Works of Youngstown Sheet and Tube Co., Youngstown, Ohio . . . Unit installed in extremely limited space, necessitating great care in design and in placement of auxiliaries and accessories . . . Duplex forced and induced-draft fans . . . For emergencies, Bunker C fuel can fire the boiler to about one-half rating . . . Special safety devices and interlocks in automatic combustion control system for purging furnace or to shut down boiler if pilots go out on gas burners . . . New unit, burning 88 Btu-per-cu-ft gas, makes one-third as much steam as six older boilers in existing steam plant . . . Internal chemical feed under electronic control . . . Size of this new unit indicated by fact it contains 26.5 miles of tubes

By **PAUL R. DUFFEY** Power Engineer, The Youngstown Sheet and Tube Co.

tinuous peak operation of the older steam generating units. Accordingly, at the earliest opportunity, in 1947 such a unit was planned and has now been installed as shown in this article. It has many outstanding features and constitutes a long step forward in industrial steam plant practice, just like its predecessors.

Additional iron and steel manufacturing resulted in an expanded supply of blast furnace gas. Accordingly, the new steam generating unit was designed to be fired primarily with this blast furnace gas, which otherwise had to be discharged to atmosphere.

New Unit Installed in Limited Space

In designing the new unit, a most important problem was to fit it into an extremely limited space. As shown on Fig. 10 the existing power house containing the six boilers installed in 1928 could be extended to the west a distance of only 46 ft. Reasons for this were: The existing blast furnace gas main led across from the blast furnaces, as shown on Fig. 10, in a position that could not be changed; a roadway had to be left open to the west; a railroad track serving important production facilities and running diagonally past the northwest corner of the boiler plant, could not be re-located.

Accordingly, the new No. 7 unit was designed to fit into the space shown in Fig. 10. The severe limitation of space is illustrated by the fact that when the retractable soot blower elements of the new unit, to

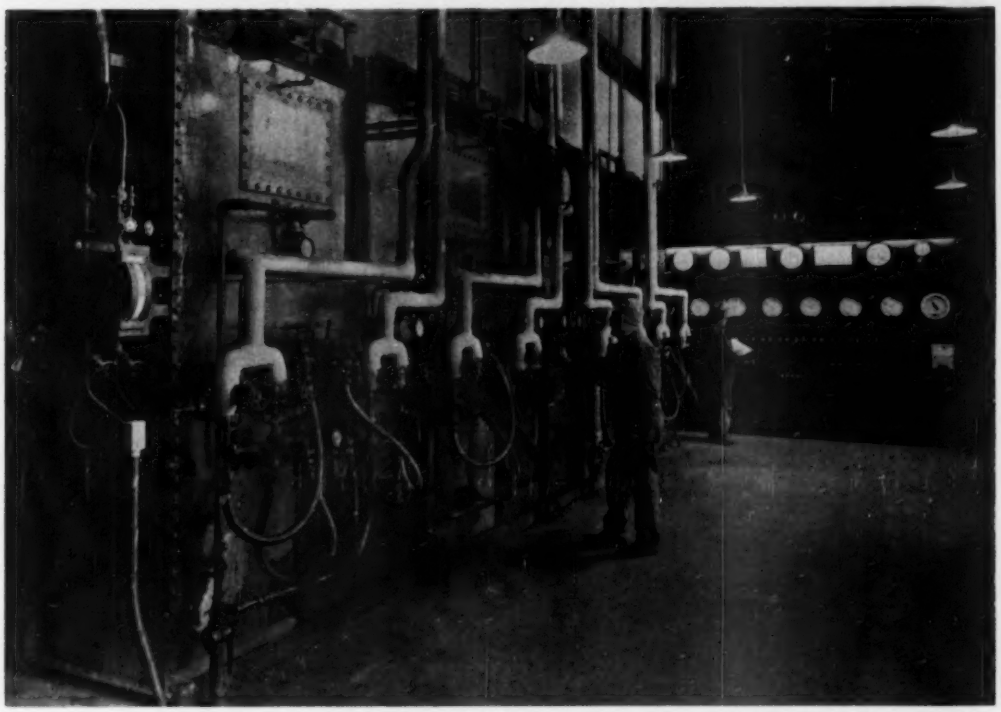


Fig. 2. View on operating floor, new steam generating unit No. 7, Campbell Works boiler plant. Shows gas burners, oil burner piping coming down from manifold on level above, see Fig. 16; all manual and automatic combustion control and instruments for the unit are centralized on control panel in background

be described and shown later, are fully retracted, there is only 4 in. clearance between them and the west wall of the building.

As noted above, the new steam generating unit is designed to burn wet, washed blast-furnace gas containing at times 0.50 grains of saturated dust per cubic foot of gas as fired and having heat value of 88 Btu per cubic foot. This means that to develop rated continuous output of 350,000 lb of steam per hr in this steam generating unit, it is necessary to burn 98,000 cu ft of gas per minute.

To burn this large volume of gas an adequate furnace volume was necessary, and as a consequence, because of the limited floor area for the unit, the furnace had to be high as shown in Fig. 1.

The list of principal equipment for No. 7 steam generating unit, given

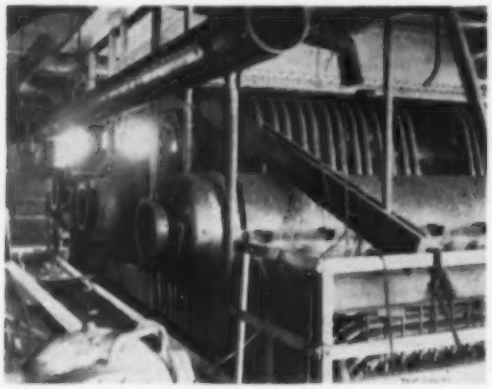


Fig. 3. Construction view, showing three upper drums of steam generating unit No. 7; end of economizer drum in far rear

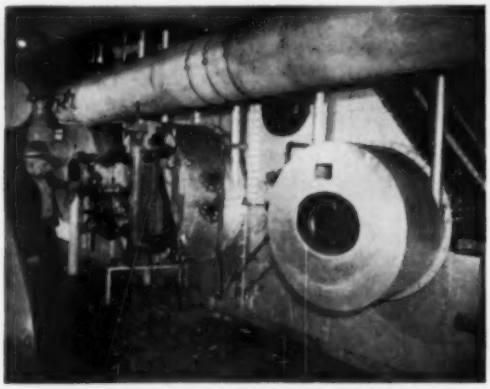


Fig. 4. Three upper drums of Fig. 3 after insulation and casing were applied. Insulation on drum ends sectionalized

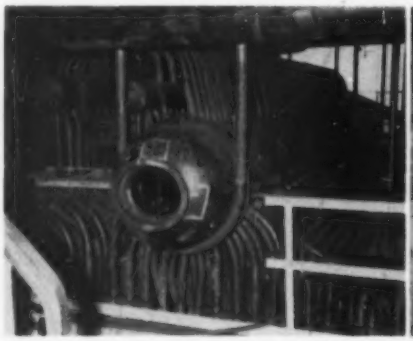


Fig. 5. Front drum and superheater headers under erection on steam generating unit No. 7

Fig. 6. View of portion of east side furnace wall tubes during erection

Fig. 7. Front wall tubes where vertical tubes weld to hopper tubes

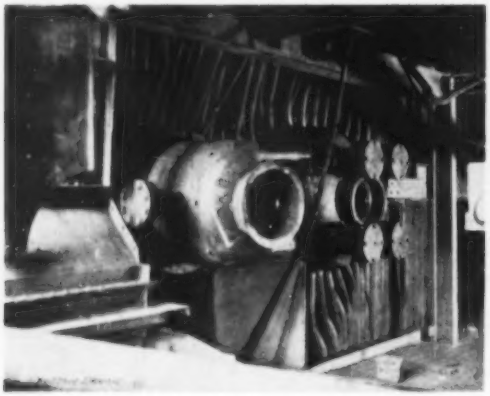


Fig. 8. Construction view showing bottom drums. Bottom economizer drum at left. At right, bottom boiler drum, showing connections for two sets of attemperators installed in drum

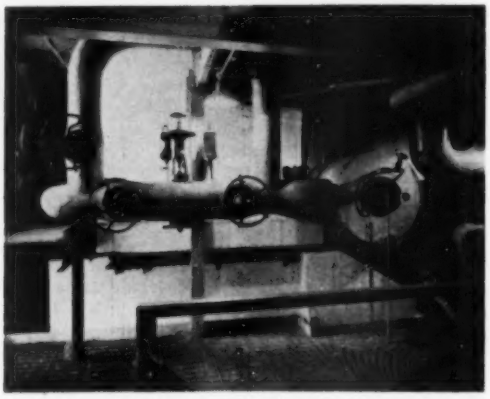


Fig. 9. View of bottom economizer drum, water connections and at right, attemperator connections, at same level as Fig. 8, after insulation and casing were applied

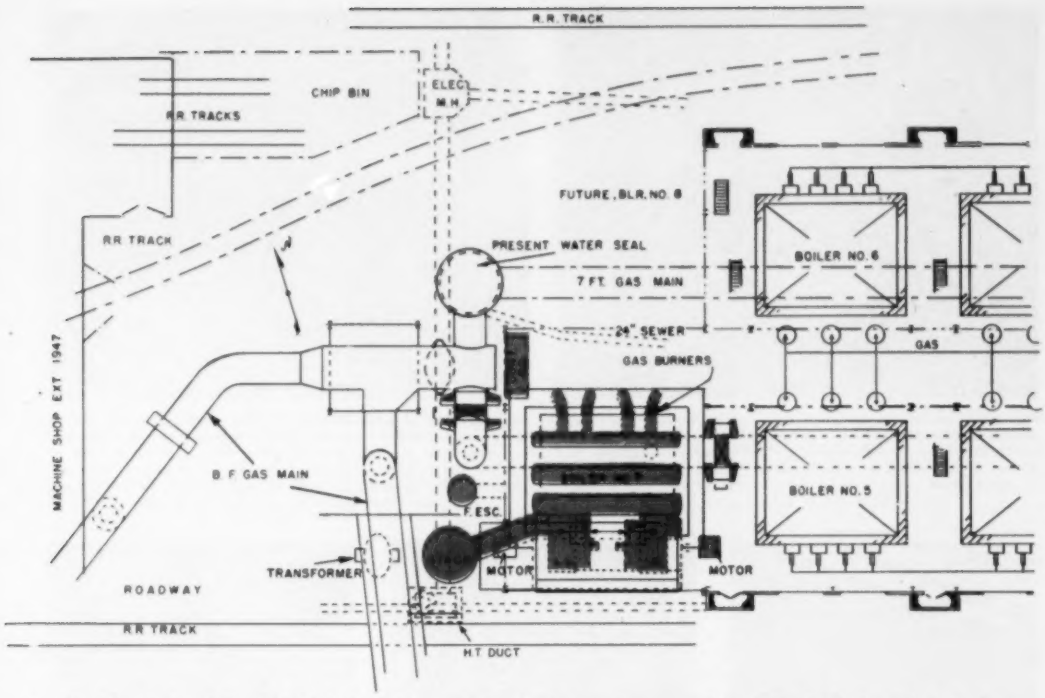


Fig. 10. General plan of Campbell Works boiler house extension showing new steam generating unit No. 7. This shows why boiler house extension to west is limited, necessitating careful design to get unit No. 7 into space available

on page 60, shows all the dimensions, capacities, and technical details of the boiler and its auxiliaries and accessories. The photographs show many of the details while the unit was under construction.

Details of Steam Generating Unit

The boiler is of the 4-drum, vertical, bent-tube design built for continuous delivery of 350,000 lb per hr of steam at 400 psig and 700 F measured at the outlet side of the non-return valve. The boiler is of the single-pass type, having no baffles in it; and is equipped with a pendant type, non-drainable superheater, with two outlets discharging steam. These are arranged so that the superheater will discharge steam into two sets of submerged mud-drum type steam attemperators for steam temperature control or will by-pass them and deliver steam direct to the main steam header.

The steam attemperators are installed in the bottom or mud drum of the steam generating unit, as shown in Fig. 1 and Fig. 8. The steam temperature is controlled automatically by operation of two butterfly type control valves in the steam lines leading to and from the attemperator.

The boiler heating surface is 28,089 sq ft, the superheater has a heating surface of 4230 sq ft and the boiler is also equipped with an integral, 2-drum type economizer, Fig. 1, having a heating surface of 9280 sq ft.

Feedwater enters the bottom drum of the economizer at 285 F and leaves it at 375 F. Behind the boiler is installed a multi-tubular type air preheater of 40,000 sq ft heating surface. Flue gas leaves the boiler at 940 F, leaves the economizer at 790 F and leaves the air heater at 600 F, while the air enters the air preheater at 80 F and leaves at 565 F.

An idea of the size and capacity of this modern steam generator is given by the following tabulation of the lengths of tubing included in the unit as follows:

3¼" boiler tubes	16,650 lineal feet	=	3.14 miles
2 " boiler tubes	25,720 lineal feet	=	5.22 miles
3¼" water wall tubes	6,200 lineal feet	=	1.16 miles
2½" air preheater tubes	61,000 lineal feet	=	11.5 miles
2 " superheater tubes	11,720 lineal feet	=	2.18 miles
2 " attemperator tubes	980 lineal feet	=	0.18 miles
2 " economizer tubes	16,350 lineal feet	=	3.1 miles
	138,620 lineal feet	or	26.48 miles

Fuel Burners and Auxiliaries

To burn the wet washed blast furnace gas as the primary fuel, four multiple-tip, intertube type blast furnace gas burners have been installed, as shown in Fig. 1. Figure 17 shows the details of one of these burners. Each burner is arranged with two pilot burners or gas torches of the Bunsen burner type burning coke oven gas for the sole purpose of maintaining ignition of the blast furnace gas. These pilot lights are ignited at all times when the steam generating unit is in service.

In addition, eight Y-jet steam oil atomizing burners have been installed, as shown in Fig. 1, for burning Bunker C fuel oil efficiently to maintain approximately one-half the continuous rating of the boiler or 175,000 lb of steam an hour when burning oil alone. A complete independent fuel oil system has been provided, as shown in Figs. 2 and 16, which may be manually started and controlled from the main operating panel shown in Fig. 2. Provision has been made in the design to permit later installation of pulverized coal burners, if necessary or desirable. The required ducts for tempering air and secondary air have been installed at this time.

Particular care was used in designing and constructing all flues and duct work for this unit. The boiler flues for hot gas and dust hoppers are all constructed of ⅜-in. steel plates of welded construction where practicable and all reinforced. Some are refractory lined or gunite lined or both, some are bare with external insulation. All cold-air,

Fig. 11. View of the complete chemical feed system, all under control of electronic system to proportion chemical feed to flow of boiler feedwater. Center:—three controlled volume chemical feed pumps; Right:—chemical mixing tank and pump supplying chemicals to storage tank above pumps; Left:—electronic control for system. System operates as described in Ref. 3

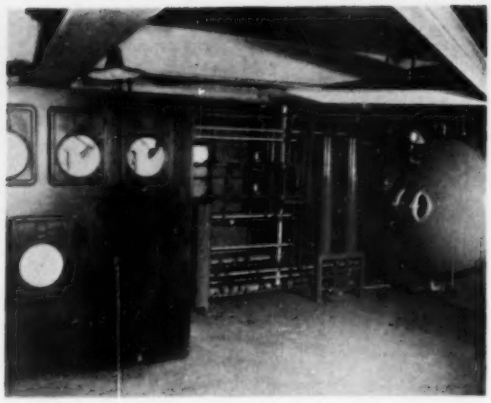


Fig. 12. View of equipment for insuring supply of clean, dry air to automatic controls and instruments, steam generating unit No. 7. Compressed air from general mill system is stored in tank at right, of size to provide 15 min. storage; then passes to condenser filters at left of tank for dirt and moisture removal, thence through coke filters and then to control equipment

Fig. 13. Construction view of one of the 232,000-cfm induced draft fans, showing ductwork

Fig. 14. View of one of the 232,000-cfm induced draft fan and its driving motor after insulation was installed

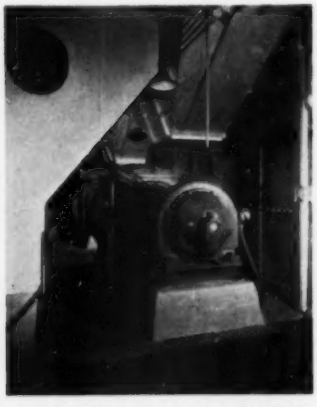


Fig. 15. View of the two 56,000-cfm forced-draft fans and their driving motors, and ductwork, after insulation was installed

Fig. 16. Oil supply manifold and control valves for oil burners on floor above operating floor of Fig. 2.

Fig. 17. Assembly of one of the blast furnace gas burners. These are each intertube type, each 60 in. long, with 5 tip openings

Fig. 18. View of the lower section of the 12-ft-diameter steel stack at beginning of erection, showing hopper bottom

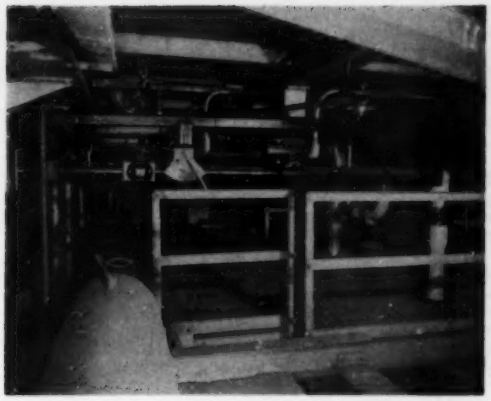


Fig. 19. View of several of the telescopic soot blower elements; soot blowing medium is steam, blowers are driven by electric motors

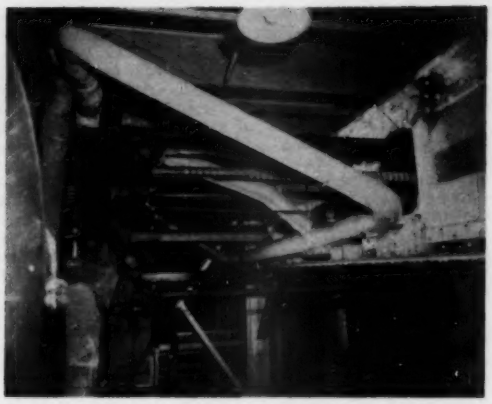


Fig. 20. View of several of the retractable air-motor-driven soot blower elements; in retracted position there is only 4 in. between them and the building wall, showing how restricted was the space

tempering-air and hot-air ducts are constructed of 0.141 U. S. Standard steel plate gage steel, wherever practical are of welded construction and all are adequately reinforced and supported in place.

Expansion elements are liberally used. All are of the multiple bellows type, outside flanged with gasketed and bolted joints, inside guided and externally shielded.

The blast furnace gas burners noted above receive their supply of gas from the existing 84-in gas header system in the boiler house. This header system is in effect a rectangular loop from which all the six existing boilers draw their gas supply.

For the control of gas to each burner its riser from the loop header is equipped with a 36 in. butterfly valve, operated by a control drive which may be positioned either manually or automatically through selector valves and relays mounted on the main control panel and is interlocked with other functional elements of the combustion control system as explained below.

In addition, these ducts are equipped with four 36-in., motor-operated remote-controlled, blast-furnace gas, shutoff valves and two 84-in. shutoff valves, so that the entire gas supply system may be shut off this unit for inspection and maintenance.

Because the blast furnace gas fuel, even after being washed, still contains up to 0.50 grains per cu ft of saturated dust, it was necessary to install a carefully-designed soot blower system in this steam generating unit. It has been equipped,

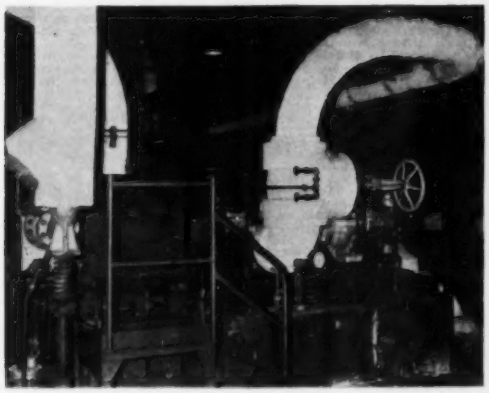


Fig. 21. The new 1500-gpm, 1510 ft head, boiler feed pump unit, driven at 3600-rpm by a direct-connected 682-hp, 400-psig, 700-F steam turbine exhausting at 150 psig and 500 F

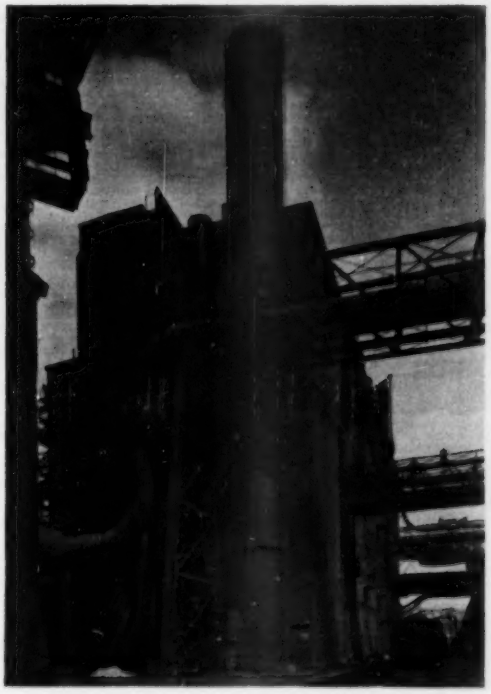


Fig. 22. Exterior view of Campbell Works boiler house, from end housing new steam generating unit No. 7. Blast furnace gas pipe line, running horizontally across in foreground, is one factor that limited further extension of plant. Small stack to left of large one is the spiral fire escape. Pipe bridges in right rear carry steam and water lines from and to other parts of steel plant

therefore, with seven electric motor-driven telescope units; four retractable air motor-driven units; and two model G9B air motor driven units, a total of 14 units installed, but none in the air preheater. These soot blowers all use 400-psi steam as the blowing medium. The furnace bottom is equipped with a refractory-lined dry ash hopper with a water seal, Fig. 1; from this hopper the material is discharged by a hydraulic sluicing system, which also handles the dust discharged from the boiler and air heater hoppers.

The steel stack for this boiler, Fig. 21, also has a hopper bottom for collection of any dust that may deposit there. The riveted steel plate stack is 12 ft in diameter and 125 ft high with a 2½ in. lining of lumnite cement and haydite applied by the gunite method.

Forced and Induced-Draft Fans

Combustion air for the unit is supplied by two forced draft fans each of 56,000 cfm capacity at 105 F and 10.4 in. H_2O discharge pressure. Each fan has controlled double inlet vanes protected with removable safety screens, and each fan is driven at constant speed of 870 rpm through a flexible coupling by a 150-hp, 2300-v squirrel cage motor for across the line starting. Two induced fans each of 232,000 cfm capacity at 645 F and 7.5 in. H_2O draw the flue gas through the air preheater and discharged it to the stack. Each fan is provided with two sets of inlet box multiple-louver type ball-bearing dampers with external control mechanism. Each fan is driven at constant speed of 700 rpm through flexible couplings by a 600-hp, 2300-v squirrel cage motor for across the line starting.

As may be seen from Figs. 1 and 22, also Fig. 10, because of the limited space, one of the induced draft fan motors located at ground level had to be located just outside the limits of the boiler house west wall in a small lean-to built especially to house it.

The induced draft fans in this installation are built to a design that was worked out some years ago by a very interesting and close collaboration between the fan manufacturer and the writer and other engineers of The Youngstown Sheet & Tube Co. See Reference 2.

Feedwater Preparation and Pumping

In the Campbell Works boiler plant, all boiler feedwater is treated in a central water treating system, therefore no new general treatment system, except for the internal chemical treatment noted below, had to be installed for the new steam generator. The existing water treatment system was installed a number of years ago by the William B. Scaife Co. and produces a water of reasonably satisfactory characteristics for the boilers.

The softened water from this treatment system, which is located in another building, is supplied to a boiler feed header in the boiler house by the boiler feed pumps of the existing station. However, to provide the required additional ca-

Principal Equipment for No. 7 Steam Generating Unit, Campbell Works

Steam Generator Components

Boiler—1 Stirling type boiler, 350,000 lb per hr actual steam, continuous rating. Steam 400 psig, 700 F on outlet side of non-return valve. Boiler heating surface 28,089 sq ft. Complete water-walled furnace with slope tubes and headers forming hopper bottom. Water wall heating surface, 5274 sq ft. Boiler is single pass and equipped with 4230-sq ft heating surface, pendant-type non-drainable superheater with two outlets discharging steam into and/or bypassing two (2) sets of submerged, mud-drum type steam attemperators, all with Bailey Meter Co. automatically operated temperature control, in turn operating two Hagan butterfly type control valves. Boiler equipped with integral two-drum type economizer, heating surface 9280 sq ft; feedwater entering bottom drum of economizer at 285 F, leaving at 375 F. The Babcock & Wilcox Company.

Air Preheater—multitubular type, external heating surface 40,000 sq ft. Air enters at 80 F and leaves at 565 F.

Burners—6 multiple-tip, intertube-type blast-furnace gas burners, each 60 in. long, having 5 tip openings. Each burner has quick-open-and-close lance door for burner lancing. This unit designed to burn wet-washed blast-furnace gas, 0.50 grains saturated dust per cu ft gas as fired, containing 88 Btu per cu ft, as primary fuel. The Babcock & Wilcox Co.

Provision for future pulverized coal burners; required tempering and secondary air ducts have been installed at this time.

8 Y-Jet B & W Steam-oil atomizing burners installed for Bunker C fuel oil to approximate one-half continuous rating of boiler on oil alone. Complete fuel oil system, manually started and controlled from main combustion operating panel.

Pilot Lights—for coke oven gas, B & W, 2 per blast-furnace gas burner, for sole purpose of maintaining ignition of blast furnace gas. Ignited at all times steam generator is in service.

Flues and Ducts—Boiler flues (hot gas) and dust hoppers all of ¼ in. steel plate, welded construction where practical and all well reinforced. Some refractory lined and/or gunite lined, some bare with external insulation. All cold air, tempering air and/or hot air ducts constructed of 0.141 U. S. Std. steel plate gage steel; wherever practical welded construction; all adequately reinforced and supported in place.

Expansion elements liberally used; all of multiple bellows type, outside flanged, gasketed and bolted joints, inside guided and externally shielded.

Forced Draft Fans—2 type $1001-TVID, 870 rpm, 56,000 cfm each at 105 F and 10.4 in. H_2O. Each fan provided with controlled double-inlet vanes, protected with removable safety screens. Each fan direct connected through Falk flexible couplings to Westinghouse 150-hp, 3-phase, 60 cycle, 2300-v, continuous-duty, open-type squirrel-cage induction motor, across-line starting. B. F. Sturtevant Div., Westinghouse Electric Corp.

Induced Draft Fans—2 $1010-TVID, 700-rpm, 232,000 cfm each at 645 F and 7.5 in. H_2O. Each fan provided with two sets of inlet-box multiple-louver type, ball-bearing dampers, external control mechanism. Each fan direct connected through Falk flexible coupings to Westinghouse 600-hp, 3-phase, 60-cycle, 2300-v, continuous-duty, open-type, squirrel-cage induction motor, across line starting. B. F. Sturtevant Div., Westinghouse Electric Corp.

Safety Valves and Steam Gages—(Consolidated valves) Manning, Maxwell & Moore, Inc.

Water Columns and Remote Water Level Indicators—2 each, Yarnall Waring Co.

Boiler Non-Return Valve—Edward Valves, Inc.

Boiler Stop Valve—Chapman Valve Mfg. Co., motor operated, with Cutler Hammer Co. Operating Control.

Boiler Feedwater Stop-and-Check Valve—2, Edward Valves, Inc.

Blast Furnace Gas Burner Control Valves—4, B. S. Products Co. 36 in. butterfly controlled by Bailey Meter Co. drives, operated manual—automatic through selector valves and relays mounted on main control panel and interlocked with other functional elements of combustion control system.

Blast Furnace Gas Shut-Off Valves—6 (two 54 in. and four 36 in.) motor-operated, remote control, Edgar E. Brostus Co., Inc.

Boiler Miscellaneous Valves—Edward Valves Inc.; Walworth Co.; Chapman Valve Mfg. Co; Manning, Maxwell and Moore, Inc.

Soot Blowers—7 Model T-11, electric-motor-driven, telescopic units. 5 Model I. K. retractable air-motor-driven units; 2, Model G9B air-motor-driven units. Total 14 units installed, none in air-preheater. Diamond Power Specialty Co.

Ash and Dust Handling—Solenoid-operated manually-operated dust-unloading valves, and Hydro-Vac Ash System with high-pressure water sluice. Refractory-lined dry ash hopper with water seal. Allen-Sherman-Hoff Co.

Steel Boiler Stack—125 ft high × 12 ft dia × 2½ in. gunite lumnite cement and haydite lining. Riveted construction. Steel plates ⅝ in. to 5/16 in. shell. Layout and specification by Y. S. & T. Co. furnished by The Babcock & Wilcox Co.

Boiler Feed Pump and Chemical Pumps

Boiler Feed Pump—1 No. 5-HMT, 1500-gpm, all cast-steel casing, centrifugal pump. Suction head 364.5 ft. Delivery head 1510 ft 3600 rpm. Ingersoll-Rand Co.

Direct-connected through Falk flexible coupling to Worthington-Moore Type 32 RH, 682-hp, back-pressure steam turbine, 400 psig, 700 F initial steam; exhausting at 150 psig, 500 F. Turbine has constant-speed oil relay governor, Foxboro constant-pressure control. Entire pumping unit mounted on integral fabricated steel-base plate; separate lubricating and governor oil tank; Andale oil coolers, strainers and transfer valves. Pump in series with other boiler feed pumps and operates in cycle supplying other boilers with feedwater.

Boiler Feedwater Control—Two 3-element feedwater controls installed ahead of economizer inlet nozzles; remote manual and automatic operation from main control panel. Drum level control and feedwater metering, integrating and recording all tied into this cycle of operation. Feedwater meter equipped with contactors and potentiometers for control of the direct chemical feed system. Bailey Meter Co.

Chemical Feed Pumps—Three controlled-volume No. TMD-1-75-58-SM, simplex type, stem valve No. 1 pattern, 20-gpm, chemical feed pumps. For feeding sodium phosphate directly into boiler drum and sodium sulphite direct into boiler feed line ahead of economizer inlet. Each pump driven by G. E. 1½-hp, 230-v, d-c, totally-enclosed motor, through Cleveland RH-50 speed reduction unit. Each pump controlled through G. E. Thymotrol system and Bailey feedwater meter potentiometers. Milton Roy Co.

Chemical Mixing and Batch Circulating Pump—1 motor driven Ircamet chemical pump, delivers chemical from common batch mixing and circulating tank directly to overhead storage tanks. Ingersoll-Rand Co.

Chemical Mixing—Recirculation and batch storage and feed tanks, 1 2-ft × 3 ft 6 in. steel tank, with a removable Tyler Monel Wire Cloth ½ in. sq openings × ¼ in. round wire, set in top of tank for dumping raw chemicals into tank. Tank provided with filtered water connection, recirculation line from elevated tanks and chemical pump suction and drain in bottom of tank.

2 4-ft × 7 ft 6in. × 4 ft 6 in. elevated batch chemical storage and delivery steel tanks with hinged tight covers and breather vents, installed 9 ft above floor elevation, each tank delivers chemicals by gravity into respective pump suction lines as required. Tanks provided with sight glasses, fill lines, recirculation lines, overflow lines and washout drain lines.

pacity, it was necessary to install a new boiler feed pump. This pump is in series with other boiler feed pumps and operates in the common boiler feedwater circuit.

The new boiler feed pump unit shown in Fig. 21 consists of a 1500 gpm, 3600 rpm centrifugal pump, designed for delivery head of 1510 ft (650 psi). It is driven by a 682-hp back pressure unit steam turbine, taking throttle steam at 400 psig, 700 F from the main steam header and exhausting at 150 psig and 500 F to the low pressure headers of the mill. The turbine drives the pump through a flexible coupling and is equipped with a constant-speed oil-relay governor and constant-excess-pressure control.

Feedwater supply to the boiler is controlled by two 4-in. three-element feedwater control valves installed ahead of the economizer inlet nozzle.

For internal chemical treatment in the boiler, a complete controlled-volume chemical feed system is installed, as shown in Fig. 11 and described in the list of equipment. This system feeds di-sodium phosphate directly into the boiler drum and sodium sulphite directly into the boiler feedwater line ahead of the economizer inlet. The system includes three controlled-volume, simplex-type 20-gpm chemical feed pumps each driven by a one-half horsepower, 230-v d-c motor, indirectly connected to the pump through a speed-reduction unit. Each pump driving unit is controlled, through an electronic control system, (see Reference 3) by a system of contactors and potentiometers forming part of the 3-element feedwater controller noted above. This system feeds chemicals in the desired proportion to feedwater flow.

In recent years, because of changes in the heat balance of the plant, the six evaporators installed in 1928 to supply 150-psi process steam to the mill have been converted into feedwater heaters, but by a manipulation of hand and automatic controls can be converted to evaporate water if desired.

One of the outstanding features of the new steam generating unit installation is the completeness of the automatic combustion control system and other automatic features of control.

Details of Combustion Control

The combustion control system is air operated, designed for automatic or manual control of the unit when burning blast furnace gas and equipped with provision for manual control of fuel oil burning for producing about 175,000 lb of steam per hour.

Compressed air from the general steel plant air system is used as the operating medium of this control system. Air from the general system enters an air supply storage tank, Fig. 12, large enough to supply control air for the system for 15 min. From this tank the air passes through special condenser type filters for removal of dirt and moisture, and then through coke filters

(Continued on page 119)

The Youngstown Sheet & Tube Co., Youngstown, Ohio

Fuel Oil System

Fuel Oil Pump—1 Fuel Oil System type 2-GR double-helical-gear, internal-roller-bearing, rotary pump, 40 gpm, 860 rpm, 260 psig, discharge pressure at 160 F, 1200 SSU fuel oil. Worthington Pump & Machy. Corp.

Fuel Oil Underground Tank Heater—Double coil set vertically in tank with pump suction line between inner coils. Coil by Rempe Co.

Fuel Oil Strainers—2 duplex type 104-B & 1042-B with change over valves. One coarse strainer on suction side of pump and fine strainer in discharge line. Andale Co.

Fuel Oil Discharge Heater—1 single-pass type 5066—Size 81. Andale Co.

Fuel Oil Flow Meter—2-in. area meter with Telemeter transmitter—spring loaded type. Bailey Meter Co.

Fuel Oil Temperature Regulation—Leslie Co.

Fuel Oil Flow Regulation to Individual Burner Groups—Bailey Meter Co. diaphragm operated oil flow control valves, manually operated only from control panel.

Atomizing Steam Pressure Control—Pressure regulating valves, to maintain a constant excess of atomizing steam pressure over burner oil pressure. A. W. Cash Co.

Oil Burners and Steam Atomizing Control to Individual Burners—Hand-operated flow valves. National Airoil Burner Co.

Combustion Control, Metering Equipment and Panel Board

Combustion Control System—Air-operated manual-automatic, equipped with provision for manual control of fuel oil burning. Bailey Meter Co.

Compressed air from general works system is used for operation of controls. This air enters 15-min control air supply storage tank; from this tank air passes through Hankinson Condensi-filters for removal of dirt and moisture, then through Bailey coke filters, then into the control apparatus.

Principal metering equipment all supplied by Bailey Meter Co., except as noted, consists of:

A. Steam Flow Meter to record and integrate steam flow.
B. Feedwater Flow Meter to record and integrate feedwater flow and record feedwater pressure. Includes transmitting element for operation of remote receiver for control of chemical feed pumps.
C. Boiler Drum Water Level Recorder.
D. Total Blast Furnace Gas Flow, Total Fuel Flow- Air Flow Ratio meter; to indicate and record total fuel flow, record and integrate total blast furnace gas flow and record air flow.
E. Coke Oven Gas Flow Meter, to record and integrate coke oven gas flow to pilot lights, and record coke oven gas pressure.
F. Steam pressure and blast furnace gas pressure, recording only.
G. Leeds and Northrup Co. Temperature Recorder, designed to record inlet and outlet air preheater air and gas temperatures, economizer water temperatures; superheater steam temperature.
H. Oil flow meter to record and integrate oil flow, record oil pressure.
I. Gas failure and air failure alarms including indicating lights and megaphones.
J. Conductivity recorder, including Straub sample degassing unit and conductivity cell.
K. Bailey Multipointer Draft Gages to indicate:
Blast Furnace gas flow and Secondary Air Pressure to each of the four burners. Air Preheater inlet and outlet drafts, and air pressures, and furnace draft.
Parker blow down manifolds are utilized to regulate each pointer and provide for safe compressed air blow down.
L. 1 12-in. dial electric clock. 3 12-in. dial, indicating **M. M. & M.** Co. pressure gages—feedwater pressure in, saturated-steam-drum pressure and superheated-steam main line pressure.
M. 1 Steel Plate operating panel ¼ in. × 8 ft 6 in. × 14 ft 7 in. × 5 ft. Panel mounted on Firestone vibration dampeners. Panel factory piped and wired.
N. Complete Combustion Control equipment.
O. Special safety devices and interlocks as noted in text.

Piping and Electrical Work

Station Piping Layout—design and detailed specifications by engineering department of Youngstown Sheet and Tube Co. The Dravo Corp. of Pittsburgh, Pa., contractors for shop details, fabrication and field erection. Y. S. & T. Co. purchased all valves; and furnished, from their pipe and tube mills, all steel pipe used by Dravo Corp. Welding ends, long radius Tube Turns used throughout wherever practical.

Insulation for steam generating unit and all piping to meet Y. S. & T. Co. specifications. Johns-Manville products furnished and applied by Industrial Roofing and Insulation Co. (Youngstown).

Electrical Work—Layout, design, specify and order major equipment for purchase by Y. S. & T. Co. Field materials and erection by Carlson Electric Co. (Youngstown).

Layout—Design—Specification—Construction

Layout drawings and general specifications for entire project by engineering department of Youngstown Sheet and Tube Co. this information then distributed for design and detail to: The Lombard Corp. (Youngstown)—for building, foundations and entire structure.

Building Steel taken from Lombard Corp. drawings for shop details and fabrication by Fort Pitt Bridge Co. (Pittsburgh). Floor grating to F. P. from Blaw-Knox Co. Field erection by Hunter Construction Co. (Youngstown).

Piling furnshed and placed by the Raymond Concrete Pile Co. (Youngstown).

Reinforced Concrete for foundations, footers and floors supplied by Boardman Supply Co. (Youngstown) and placed by J. D. Fowler Co. (Youngstown).

Building Siding, insulation, roof decking, wall ventilators (adjustable louver type) and roof ventilators by H. H. Robertson Co.

Window Sash furnished by The Truscon Steel Co. (Youngstown), erected by Hunter Construction Co.

Steam Generator, Flues and Ducts, and Stack erection, including miscellaneous items such as fans, motors, Bailey panel and combustion control apparatus, chemical feed tanks etc., all by the Babcock and Wilcox Co., refractory and stack lining sublet to Rust Furnace Co. (Pittsburgh).

Blast Furnace Gas Piping furnished, fabricated and erected by The W. B. Pollock Co. (Youngstown).

Paint furnished, The American Marietta Paint Co. (Chicago) to meet color scheme of Y. S. & T. Co. application by Y. S. & T. Co.

Spiral Safety Slide, furnished by Potter Manufacturing Co. (Chicago), erected for Potter by Hunter Construction Co.

Fire protection consisting of a wet high-pressure line from basement to roof building with standard 2½ in. fire hose outlets and 100 ft of hose with nozzle at each operating level.

CO_2 hand extinguishers liberally located. All fire fighting equipment is painted bright red and protected in sealed metal cabinets. All this equipment specified by and regularly inspected by, property protection division of Y. S. & T. Co.

The Determination *of Dissolved Oxygen in Boiler Waters*

The detrimental effects of oxygen in boiler feedwater are too well known to require consideration here but the determination of the amount of dissolved oxygen in boiler waters is a matter of great importance and one in which all boiler plant operators are vitally interested in. During the years many methods have been devised and formulated for the determination of the oxygen content but unless one is really well versed in the subject, the many methods available is a source of confusion. For this reason, we are pleased to be able to present this able and comprehensive review of the subject together with an extensive bibliography by Messers Young, Pinkney and Dick. It not only outlines all the principal methods but considers their relative advantages and disadvantages, an article you will want to keep for reference

By R. S. YOUNG, E. T. PINKNEY, and R. DICK

Nchanga Consolidated Copper Mines Limited, Chingola, Northern Rhodesia, South Africa

THE DETERMINATION of dissolved oxygen in boiler waters has been the subject of a large number of papers in chemical literature. It, therefore, appears desirable to review and critically evaluate the various procedures advocated, to point out promising lines for future investigation, and to appeal for a satisfactory standardization of methods by power plant chemists and others concerned with this problem.

For 60 years the method of Winkler (65)[1] has been the basic procedure for the determination of dissolved oxygen in waters. Although it was realized that the quantity of oxygen in boiler feedwater was much lower than in natural waters, industrial chemists have continued to use the Winkler procedure or one of its numerous modifications in power plant work. The trend towards higher steam pressures, with the emphasis on reducing dissolved oxygen to a very low figure, together with improvements in de-aerating equipment, have resulted in the necessity for accurately determining such very low oxygen concentrations as 0.01 ml per liter or less. For this purpose a number of refinements and modifications of the Winkler procedure have been proposed.

[1] The numbers refer to the papers in the reference list at the end of this article.

The Winkler method is based on the fact that in alkaline solution oxygen oxidizes manganous ion to magnetic, and the latter in turn oxidizes iodide ion to free iodine in amount equivalent to the oxygen originally present. After acidifying the solution, the free iodine is determined by titration with a standard solution of sodium thiosulfate, using starch as internal indicator. The reactions occurring may be expressed thus:

$$MnSO_4 + 2KOH \longrightarrow Mn(OH)_2 + K_2SO_4$$
$$Mn(OH)_2 + O \longrightarrow H_2MnO_3$$
$$H_2MnO_3 + 2H_2SO_4 + 2KI \longrightarrow K_2SO_4 + MnSO_4 + I_2 + 3H_2O$$
$$I_2 + 2Na_2S_2O_3 \longrightarrow 2NaI + Na_2S_4O_6$$

Many substances such as nitrates, ferrous salts, organic matter, and sulfites interfere with the method, but in modern boiler feedwater these substances, with the exception of sulfites, are either absent or present in negligible quantities.

The development of a suitable procedure for dissolved oxygen determinations is not facilitated by our present imperfect knowledge of the allowable limits of oxygen for different types of boilers. It is sometimes stated that for medium pressure boilers in the range of 300-400 psi the oxygen content of the feedwater should not exceed 0.02 ml per liter. We have no proof, however, that this figure is correct, or that corrosion will occur with 0.05 or even 0.1 ml oxygen per liter. In this state of uncertainty and conflicting opinions among mechanical engineers on the relation between dissolved oxygen content and incidence of corrosion in boilers it is not surprising that chemists have failed to standardize a suitable procedure for low oxygens. On the other hand, probably many of the conflicting results of corrosion studies can be

ascribed to differences in procedures for determining oxygen.

There are several factors which make the accurate determination of dissolved oxygen in boiler waters a difficult analytical task. These include the rapid changes in oxygen content which may occur in a feedwater circuit, sampling and manipulation to avoid introduction of oxygen, and the inherent inaccuracies of the starch iodide reaction when dealing with small quantities of dilute solutions in the presence of traces of impurities. If 0.02 ml of oxygen per liter is permissible but 0.03 ml too high, this means that differences of the order of 0.01 ml oxygen per liter of water must be determined. It is perhaps not generally realized that, since 0.7 ml oxygen per liter of water at NTP is equivalent to 1 ppm oxygen, 0.01 ml per liter is equal to only 0.014 ppm. This, for routine work in a busy power plant or industrial laboratory, is not an easy matter, and it is little wonder that many chemists have studied the limitations of the Winkler procedure and endeavoured to improve the method.

Procedure

Many procedures, both physical and chemical, have been suggested for the determination of dissolved oxygen. A few have been listed in a recent short review on water analysis by Love (36).

1. Physical

Todt (61) described a method based on the principle that metallic pairs, such as platinum and cadmium alloys, give a definite residual current depending on the amount of oxygen reaching the noble metal electrode. In unstirred solutions the salt concentration was without influence, but in solutions agitated briskly more oxygen reaches the electrode, the current is larger and is affected by the salt concentration.

A fluorescence procedure for dissolved oxygen has been reported (34), dependent on the bright yellow-green fluorescence with adrenaline in the presence of traces of dissolved oxygen. An amount as little as 1 ml per liter can be detected but this is not small enough so it is unsuitable for dissolved oxygen in boiler waters.

Gasometric methods have frequently been advocated in dissolved oxygen work. Winkler (67) described a procedure for heavily polluted water in which the dissolved oxygen was swept out by a stream of carbon dioxide, generated from marble and HCl in the vessel of water under examination, and collected in alkaline pyrogallol. This procedure was criticized by Coste and Andrews (13) who showed that salts like ammonium chloride reduce the solubility in water of the gases of the air. Becker and Abbott (9) published a gasometric method based on the expulsion of the air in a known volume of water by solid KOH and the direct measurement of the total volume of gas before and after absorption in alkaline pyrogallol.

Brady (11) has recently described a rapid and sensitive procedure for the determination of small quantities of oxygen in gases, which may have application for dissolved oxygen determinations. It depends on the fact that an alkaline solution of sodium anthraquinone -β- sulfonate is colorless but in the reduced state it is red, and in this form reacts with oxygen quantitatively. The analysis is not affected by small quantities of hydrocarbons, carbon monoxide, carbon dioxide, or sulfur compounds.

Polarographic procedures have been described in recent years for the determination of dissolved oxygen in water. Zan'ko, Manusova, and Nikitin (71) made a comparative study of polarographic and photocolorimetric determinations of oxygen, but the latter was much higher than in most boiler waters.

Giguere and Lauzier (20), using a micro electrode of platinum, found that by taking suitable precautions it was possible to prevent the mercury from being deposited on the cathode in polarographic determinations of dissolved oxygen. They determined oxygen in sea water down to 0.02 ml per liter with a precision of 0.02 ml per liter.

Moore, Morris, and Okun (38) recommended for general use a potential of 0.6 volt against a saturated calomel electrode; this potential lies on the flat portion of the first oxygen wave. The addition of a maximum suppressor is necessary for determinations in water but not in sewage. For continuous observation in water the second wave may be used to avoid the necessity for maximum suppression, but the potential to be used will vary with the range of oxygen concentrations to be expected. The effect of the extraneous electrolytes is negligible at the potentials recommended for use. Residual currents are very small in ordinary waters and domestic sewage. They are eliminated by establishing calibration curves for the sample in question, using known dissolved oxygen concentrations. The variation of readings with temperature is linear over the range 0-35 deg C, and amounts to 1.6 per cent of the reading at 20 deg C, per degree Centigrade change.

In recent years dissolved oxygen recorders have been installed in a number of power plants throughout the world (12, 27, 31). These are based on the difference in electrical and thermal conductivity between platinum spirals in contact with pure hydrogen and with a mixture of hydrogen and oxygen. Hydrogen is generated by electrolysis and divided into two streams, one of which passes directly over two heated platinum spirals while the other is passed through the feedwater to sweep out dissolved oxygen passing over the other two heated platinum spirals of a Wheatstone bridge. If one pair of spirals is exposed to pure hydrogen and the other pair to a mixture of hydrogen and oxygen in the contact chamber, the temperatures of the two pairs of spirals will differ and a deflection of the galvanometer will be caused which is proportional to the amount of oxygen in the mixture. The galvanometer scale can therefore be

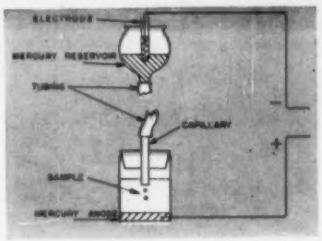


Fig. 1. The drop-in mercury electrode used in polarographic procedures

calibrated to read directly the dissolved oxygen content of the feedwater. While the recorder may not give the same oxygen value as a chemical determination, it provides a continuous record and is especially valuable to indicate the variations in dissolved oxygen content over a period. It should also be borne in mind that such recorders must be ultimately calibrated against some chemical determination, and the accuracy of the latter is therefore of the highest importance. Maintenance of these instruments is continuous and requires a highly skilled artisan, and even under the most favourable conditions it is neecssary to periodically check the recorder readings against a chemical determination.

2. Chemical

The chemical procedures for dissolved oxygen may be classified as colorimetric and volumetric.

(a) Colorimetric

Pozzi-Escot (49) treated a water sample in an atmosphere of hydrogen successively with a solution of $MnSO_4$, KI, and H_2SO_4, and collected the liberated iodine by extracting in carbon disulfide or chloroform. The extract was drawn off and compared with colorimetric standards.

Gilcreas (21) employed a colorimetric procedure using amidol but reported that certain oxidizing and reducing substances interfered, and for very accurate work the method was inferior to the Winkler test.

Bairstow, Francis, and Wyatt (7) determined dissolved oxygen in condensates and feedwaters by measuring the intensity of the starch iodide complex with the Spekker absorptiometer. They found that the blue color was constant for only a few minutes and that above 15 deg C the extinction decreased rapidly.

Pieters and Hanssen (44) studied

the influence of variables on the spectrophotometric determination of traces of oxygen in water. They found that variations of acidity from 0.005 to 0.08 N, of concentrations of KI from 5 to 80 mg per 100 ml, and of $MnSO_4$ from 0.15 to 0.61 ml of 450 gm per liter solution, all had no effect on the extinction. The quantity of starch solution had to be at least 3 ml of 10 gm per liter solution per 100 ml of sample. Temperature, however, had a marked influence on the extinction. Between 15 deg and 25 deg C the difference in extinction is more than 10 per cent; above 25

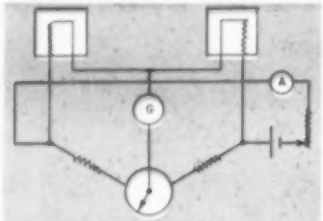


Fig. 2. The thermal conductivity method is valuable in that it provides a continuous record

deg the extinction decreases rapidly. These workers also found that the extinction co-efficient is not a linear function of the quantity of iodine in the solution measured at different temperatures when using the Spekker absorptiometer with tungsten lamp, but is a linear function when employing the Leifo photometer with a sodium lamp. Using the photometric procedure of Bairstow, Francis, and Wyatt they attained a reproducibility of the order of 0.002 ml oxygen per liter. It was also found that the stability of the starch-iodide complex was increased by the addition of potassium sulfate.

McCrumb and Kenny (37) proposed a new colorimetric procedure for dissolved oxygen, using o-tolidine as the indicator of free chlorine liberated when the higher oxides of manganese are acidified with HCl, following the initial stages of the Winkler procedure. The reactions may be represented:

$$MnCl_2 + 2KOH \longrightarrow Mn(OH)_2 + 2KCl$$
$$Mn(OH)_2 + O \longrightarrow H_2MnO_3$$
$$H_2MnO_3 + 4HCl \longrightarrow MnCl_4 + 3H_2O + Cl_2$$

These workers studied the effect of variables and found the pH must be below 2, temperature should be between 20 deg and 30 deg C, a 5-minute period was required for color comparison, and the quantity of ferric iron must be below 10 ppm. They employed a light-fast dye or a mixture of $CuSO_4$ and $K_2Cr_2O_7$ for comparison standards.

Some years later Haslam and Moses (25) advocated this procedure for oxygen in condensed steam. They made no reference to temperature conditions, but devoted considerable attention to purification of o-tolidine color. The tables of Yoe (70) for the preparation of color standards for free chlorine were used. To the sample were added 0.25 ml of 40 per cent $MnCl_2.4H_2O$ and 0.25 ml of 70 per cent KOH, followed by 1 ml HCl, and 1 ml of 1 per cent aqueous solution of o-tolidine. After 5 minutes the sample was compared with permanent standards of $CuSO_4$ and $K_2Cr_2O_7$ in 100 ml Nessler cylinders. Water of high oxygen content was mixed with oxygen-free water. The latter was prepared by sweeping out oxygen with a stream of nitrogen, and the known oxygen content of the high oxygen water was determined by the conventional Winkler method.

This procedure proposed by McCrumb and Kenny, and Haslam and Moses, has several attractive features. The determination depends on direct liberation of chlorine in the reaction and avoids that extra step of a liberation of iodine, and the intricacies of the starch iodide complex in dilute solutions. The determination of residual chlorine in waterworks practice is well established, and permanent color discs are now available for measuring small concentrations of chlorine. Muller-Neugluck (39) and Ohle (40) found this procedure satisfactory for dissolved oxygen in water.

We have devoted a lot of time at Nchanga in attempting to use this convenient procedure on a routine basis for small quantities of oxygen in boiler water, but finally without success. Low and varying results, compared with Schwartz and Gourney procedure, have been our experience, owing to instability of the o-tolidine color. The color was fixed in a flask so that no loss of chlorine occurred, but it faded to zero after standing beyond a maximum, which in itself was variable. The o-tolidine was pure enough to give satisfactory results for free chlorine in domestic water. Pieters and Hanssen (44) state that this procedure gives unsatisfactory results when the water contains organic matter or algae, but this could not be the explanation for our experience with boiler water. Whatever the reason, it appears that in some waters, at least, this procedure gives rise to difficulties.

(b) VOLUMETRIC

The volumetric procedures include the original Winkler method (53, 65, 66, 67, 68) and the bi-iodate modification of Schwartz and Gurney (1, 14, 52, 53, 62). The end point of the volumetric method may be determined either visually (1, 14, 52, 65), or by electrometric titration (1, 16, 18, 26, 43, 53, 56, 62, 64).

Winkler originally worked with water samples containing 4-6 ml oxygen per liter (65) and his procedure was obviously not intended for boiler waters. Nevertheless, his reagents manganese chloride or sulfate, hydrochloric or sulfuric acid, sodium or potassium hydroxide, potassium iodide, starch, and soduim thiosulfate are still employed in the test which bears his name. Full directions, including modifications when ferrous iron, nitrites, sulfites, thiosulfates, polythionates, free chlorine, or hypochlorites are present, may be found in authoritative reference books on water analysis (5). Work in recent years (31, 44, 69) has indicated that even under the most favourable conditions the precision of the Winkler test is 0.01-0.03 ml oxygen per liter, with 0.02 ml probably being a representative figure. For most boiler waters something better is clearly needed.

A large number of slight modifications in the Winkler procedure have been made to effect improvements or to fit the method for a specific purpose. It will be useful to comment briefly on these for reference purposes. De Graaf (23) collected the water sample under a 1-in. layer of transformer oil, and added the Winkler reagents beneath this covering. Jackson (29) criticized this procedure on the grounds that all oils have some capacity for absorbing iodine. Risch (50) recommended shaking the container for one hour in the dark after addition of the KI, NaOH, and $MnCl_2$. Friend (19) gave details of adding the reagents by capillary tubes to avoid the action of the atmosphere. Therriault (59) assured complete absorption of dissolved oxygen by causing the precipitate of manganese hydroxides to settle a second time. Loss of iodine by volatilization was prevented by titration in the sample bottle itself and by the use of large amounts of iodide. Alsterberg (4) maintained that the modifications suggested by Winkler in the presence of impurities are worthless because they assume that the losses in oxygen occur during the process of acidifying, whereas most interfering substances reduce the oxidized manganese hydroxides in an alkaline medium. Haase (24) stated that $MnCl_2$ should be added to the water before solid NaOH or low results will be obtained, and that nitrate can be removed with a few drops of 5 per cent soduim azide solution. Farmer (17) recommended $MnCl_2$ instead of $MnSO_4$, and advocated the use of a cooling coil to cool the sample to room temperature. Smoke (58) employed a micro apparatus for the Winkler test on biological investigations where small samples of 10 ml are necessary. Skopintzev and Ovehinnikova (57) described modifications of procedure in presence of nitrites, ferric salts, and chlorine. Therriault and McNamee (60) outlined modifications in the presence of organic matter, hypochlorites, and sulfite wastes. Jurewiez (32) and

Allee and Oesting (3) discussed the limitations of the Winkler procedure. Dresher (15) modified the test so that it was based on the definite relation between the amount of oxygen in feedwater and the temperature at which the blue color of the iodometric starch reaction appears. White, Leland, and Button (64) reviewed the procedure for boiler

water. Barnett (8) recommended the addition of 2 per cent sodium azide to the alkaline iodide reagent of the Winkler method to eliminate the interference of nitrites. Whiffen (63) suggested samples should be collected in a gas sampling burette, 500-1000 ml taken for titration, cooled rapidly, and titrated at temperatures below 15 deg C.

Schwartz and Gurney Modification

Schwartz and Gurney (52) improved the basic Winkler method by adding a small known amount of iodine from a standard potassium bi-iodate solution to two samples, one of which is a blank. The two determinations have a common sensitivity since the same starch solution is used and the direction of reactions is the same in both. Variations in the type of starch used, the temperature of titration, contamination of reagents, and dissolved oxygen content of reagents do not interfere with the precision of the method.

In the procedure of Schwartz and Gurney two samples are collected in series of suitable containers. To one sample, which is used as the blank, are added, in order, alkaline potassium iodide, sulfuric acid, and manganese chloride. The effect of the presence of the Winkler reagents is thus secured without fixing any of the oxygen dissolved in the water sample. To the other sample are added the reagents in their regular order: manganese chloride, alkaline potassium iodide, and sulfuric acid. If the addition of starch does not show a blue color after fixing, add 0.5 or 1.0 ml of 0.01 N potassium bi-iodate solution. Titrate as usual with 0.01 N sodium thiosulfate, using micro-burettes. Schwartz and Gurney recommended the following procedures:

A. Collect two 500 ml samples in tandem. If the addition of starch does not show a blue color after fixing with 1 and 2 ml of reagents, respectively, add 0.5 or 1.0 ml of 0.01 N potassium bi-iodate solution. The corrected oxygen concentration of the samples, using 0.01 N sodium thiosulfate, is 0.112 (2 x ml. thiosulfate $_{1\ ml}$ -ml of thiosulfate $_{2\ ml}$).
B. Collect one 250 ml and one 500 ml sample in tandem. If the addition of starch does not show a blue color after fixing each with either 1 or 2 ml of reagents, add 0.5 or 1.0 ml of 0.01 N potassium bi-iodate solution. After fixing, add 250 ml of untreated sample, collected from the same source and at the same time as the treated samples, to the 250 ml fixed sample. The corrected oxygen concentration of the samples, using 0.01 N sodium thiosulfate, is, in ml per liter, 0.224 (ml of thiosulfate $_{500}$ -ml of thiosulfate $_{250}$).

The following procedure, condensed from the paper of Daugherty (14), is typical of the present Schwartz and Gurney method using visual titration. By means of a manifold from the throttled discharge end of a cooling coil, fill simultaneously one 500 and two 250 ml bottles. Allow the bottles to overflow freely and slowly raise the manifold until all arms are out of the bottles. Stopper, and examine for entrained air bubbles.

The 500 ml sample bottle is referred to as bottle A, the 250 ml one whose oxygen content is to be fixed as sample B, and the other 250 ml one as bottle C. Add the regular Winkler reagents of the usual strength and in the regular Winkler order and quantities to bottles A and B by means of separate pipettes lowered about 2 in. into the bottles, except the acid which should be released in the necks of the bottles. Add no reagents to bottle C. Before lowering the pipettes into the bottles, allow a drop of liquid to flow out and hang on the tips of the burettes each time so that an air bubble will not be introduced. After the addition of the manganese ion and iodide solutions, stopper bottles A and B and mix the contents thoroughly by repeated inverting. Allow to stand 10 minutes, unstopper, fix with acid, stopper and again mix by inverting.

Hold all samples at 70 F or lower. Pour the entire contents of bottle A including glass beads into a large porcelain casserole. Add exactly 5 ml of 0.01 N potassium iodate or bi-iodate from a 10 ml burette. Titrate with 0.01 N $Na_2S_2O_3$ from a 5 or 10 ml burette calibrated in 0.01 ml, adding starch when close to the endpoint. Stir during the titration and record the titration value in ml as T_A.

Now titrate bottle B in the same way, after adding 250 ml of unfixed sample from bottle C to the casserole. Add 5 ml of 0.01 N potassium iodate, titrate with $Na_2S_2O_3$, and record the value as T_B. By adjusting the volumes of bottles A and B with glass beads, the difference between the volumes can be made exactly equal to 250 ml. Hence the difference between the titration values of T_A and T_B will be the titration value of a 250 ml sample.

$$(T_A - T_B) \times 0.224 = \text{ml. oxygen per liter.}$$

Electrometric Titration

In an effort to overcome the shortcomings of the starch-iodide reaction for work of high accuracy in very dilute solutions, electrometric titration has been employed to indicate the endpoint of the iodide-thiosulfate titration. Potentiometric titration procedures may be divided into two classes:

A. Those measuring the endpoint of the straight Winkler method (1, 16, 18, 26, 43, 64).
B. Those indicating the course of the Schwartz and Gurney procedure, or similar modifications of the original Winkler method (31, 53, 56, 62).

A. Electrometric Titration for Winkler Procedure

Foulk and Bawden (18) were the first to report the application of electrometric titration to iodometry. They used two platinum electrodes, both of which remained depolarized in the titration of iodine with thiosulfate. Since the galvanometer comes to a dead stop at the end point, or to a permanent displacement from a position of rest, later workers often refer to the "dead stop" end point. Hewson and Rees (26) describe an electrometric titration for dissolved oxygen in deaerated water. White, Leland, and Button (64) likewise employed electrometric titration for determining oxygen in the Winkler procedure. Perley (43) reported an electrometric procedure for power plant waters, using a small piece of platinum with a lead wire as indicator electrode and a saturated calomel cell as reference electrode.

Adams, Barnett, and Keller (1) described a potentiometric titration employing a saturated calomel electrode and a bare platinum electrode,

(Continued on page 102)

Construction of *Short Circuit Current Decrement Curves*

In determining the proper relay settings and in the selection of proper fuses it is necessary on electrical systems to have accurate data on the magnitude and characteristics of the short circuit currents that develop in various parts of the system in case of a fault. In many instances it is important to know exactly how the short circuit current decays in the first few seconds after the instant of the short. In this article, Mr. Brightman of the General Electric Company describes an easy way of constructing these decrement curves. It is a graphical method, not at all difficult once one has assembled the necessary data on the known circuit constants

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A CLOSE approximation of the magnitude of the short circuit current to be expected at any specified location and time after short circuit is a prerequisite to the determination of relay settings and fuse blowing time. In most cases its probable magnitude will be sufficiently large or constant to obviate the necessity of making allowance for reduction due to the decrement effect. There will be a few cases, however, where it is quite possible that some of the contemplated relay settings would prove to be inoperable or undesirably slow, if due allowance is not made for the fact that the fault current magnitude decays very rapidly in the first few seconds after the instant of short circuit.

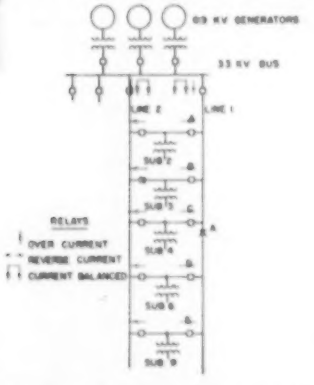


Fig. 1. Typical Power System. A system such as this is likely to require decrement curves

The purpose of this article is to describe a relatively simple and easy graphical method for constructing decrement curves, when they are needed to show this rate of decay. The method described includes provision for showing the effect of changing generator excitation. Decrement curves thus drawn are sufficiently accurate for practical purposes in setting relays and predicting fuse behavior.

The system study from which the sample decrement curves in Figs. 2 and 3 were taken is a good illustration of a case where it was necessary to construct them. This system Fig. 1 involved several 6900-33000-v generator-transformer units paralleled on a 33 kv bus, and the study was primarily concerned with the short circuit conditions and operation of the relays on the 33 kv system. There was (1) a wide range between the minimum (Fig. 4) and maximum (Fig. 5) generating capacity required under normal operating conditions, and (2) practically the total output of the generating station went out over two pairs of 33 kv feeders, any one of which had to be capable of carrying the full, high-peak load of that pair in case of trouble. Another complication was the fact that with normal parallel operation of the feeders, what little fault current there was, could be split by the parallel paths in the 33 kv distribution system after the breaker nearest the fault had opened, i.e., after Breaker C opens, the fault current contribution from L-2 to a short circuit at A divides between Breakers B and D (Fig. 1) in proportion to the relative impedance of the two current paths to A.

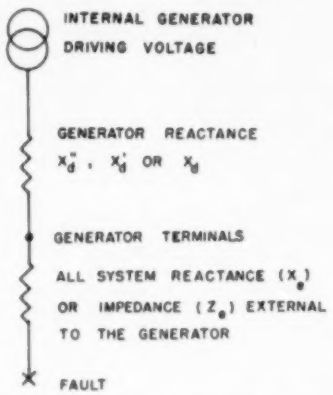


Fig. 2. Simplified System reactance diagram

Figure 2 shows the manner in which any power system can be simplified and condensed for short circuit study analysis and discussion. Internal generator and external system reactances are shown separately, since generator reactance varies with time, whereas the external reactance X_e has a constant value. There will also be times when the generator is able to restore the a-c voltage at its terminals to nor-

mal value with the fault still on, and then the external reactance only will determine the fault current magnitude.

A decrement curve shows the magnitude of the fault current at any given time between the instant of short circuit and its steady-state value a few seconds later, after the effect of transient and subtransient reactances have disappeared, and the voltage regulator, if there is one, has had time to put maximum excitation on the generator (Curves 1, 2, 3 of Figs. 4 and 5), or as may happen in some cases, bring the a-c voltage back to normal (Curve 4 of same Figs.).

Short circuit current decrement curves are simple exponential curves with corrections for variables such as changes in excitation. The slope of such an exponential curve at any given instant is such, that it would reach its steady state value in one time constant if it continued to fall at that rate. See Fig. 3. Since the curve flattens out with time after short circuit a given point on a decrement curve will actually fall about two-thirds of the distance from where it is at any instant to its steady-state value in the space of one time constant T'_d, providing there is no change in generator excitation in the interim.

The graphical method of constructing a short circuit current decrement curve is based on the premise, that the initial value of transient reactance fault current could be maintained, if there was enough excitation available to enable the generator to develop sufficient voltage "ahead" of generator-synchronous-reactance to force that magnitude of current through the total synchronous reactance or impedance of the system to the point of fault. To take advantage of this, we use the amount of excitation needed to maintain the initial symmetrical magnitude of transient reactance fault current, expressed in terms of Per cent Exciter Volts, as the starting point of an incremental curve that will represent fault-current behavior under the stated conditions. Each increment of this curve has the aforementioned slope (Fig. 3) representing the rate of fault current decay. The curve ends with the assumed steady-state excitation conditions also expressed as Per cent Exciter Volts. The various points on the curve can readily be converted, as explained in detail later, from Per cent Exciter Volts to Fault Current Values expressed in the desired units of "times normal" base current, or actual amperes.

The initial and steady-state values of the short circuit current, and the shape of the decrement curves between these limits depend on the following factors and assumptions.

A. The total transient, subtransient and synchronous reactance of the system to the point of the fault.

The total reactance in each case will consist of the generator internal reactance (X''_d, X'_d or X_d) plus the external reactance (X_e) of the system.[1]

In many cases the circuit resistance will be of sufficient magnitude to require that it be combined vectorially with the system reactance and the resulting value of impedance used instead of reactance only in order to obtain more accurate values of fault current. In the case of faults close to the power house where the current limiting factor is primarily generator and transformer reactance, the effect of machine and circuit resistance is negligible and can be ignored, except in the case of a system whose neutral is grounded through a resistor. When the fault is some distance from the power house, however, the circuit resistance may have an appreciable effect and should be combined with the system reactance to the point of fault. Only reactance-terminology has been used in most of the discussion and formulas in order to simplify the text. It is expected that the reader would recognize those cases where allowance should be made for the effect of system resistance when preparing data for decrement curve construction and substitute impedance for reactance values where necessary.

B. Whether or not the voltage regulator is in operation.

The regulator puts maximum excitation on its generator during a short circuit, except in those cases where the system impedance is high enough to limit the short circuit current to a magnitude, which the generator can carry and at the same time restore the a-c voltage to normal with less than maximum exciter output. In these cases the regulator causes the exciter to increase generator excitation until the a-c voltage is restored to its normal value, and then holds it there. When such a fault occurs, the current falls at first and then rises to that magnitude which normal voltage at the generator terminals can force through the system impedance X_e in Fig. 2. Curve 4 of Figs. 4 and 5 shows the current magnitude for such a condition.

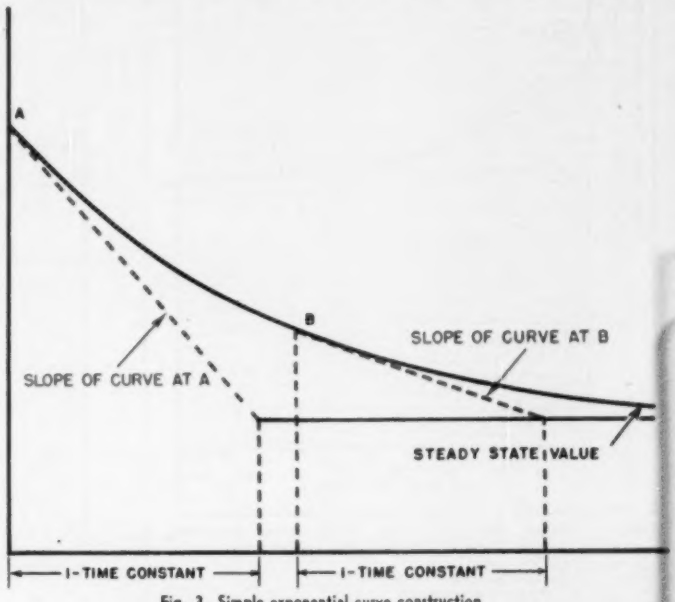


Fig. 3. Simple exponential curve construction

The regulator's effectiveness in increasing the magnitude of fault current after the first half second may mean the difference between operation and non-operation of the relays on systems of limited capacity with 2 or more relays in series, or where the fault current is divided and flows in two or more paths.

C. Exciter-rate-of-response in per cent of rated voltage, expressed in volts per second.

Unless otherwise specified, standard exciters have a nominal .0.5 per unit (50 per cent) rate of response as defined in the ASA Standards. The ASA Standard definition of exciter-rate-of-response is based on generator slip ring voltage at rated load and voltage, which is slightly less than exciter rated voltage. For this particular purpose, however, it is permissible to use the nominal exciter rate-of-response

[1] For symbol definitions see end of article.

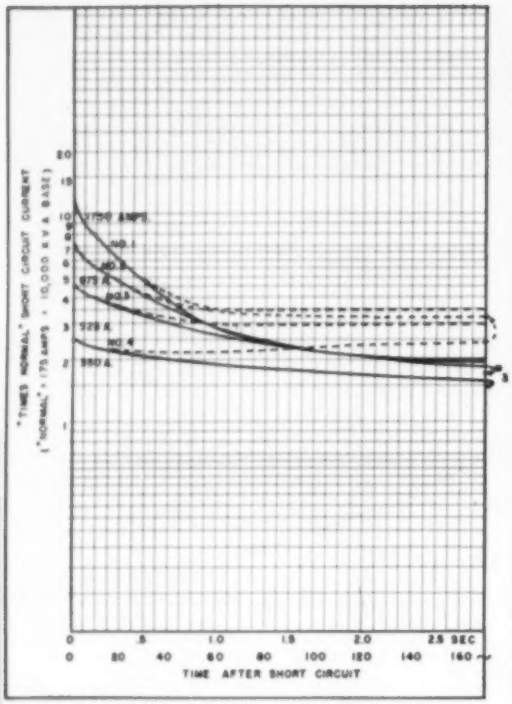


Fig. 4. (Above) Three phase short circuit current decrement curves. Three 5000-kw generators running

Solid line curves—no regulator
Broken line curves—with regulator
No. 1 Fault on 33-kv bus at powerhouse
No. 2 Fault at sub 3—Lines 1 and 2 in parallel
No. 3 Fault at sub 6—Bkrs C and D open, 2 lines paralleled
No. 4 Fault at sub 9—1 line only in use

Fig. 5. (Below) Three phase short circuit current decrement curves. Two 10,000 kw and four 5000 kw generators running

Solid line curves—no regulator
Broken line curves—with regulator
No. 1 Fault on 33-kv bus at powerhouse
No. 2 Fault at sub 3—lines 1 and 2 in parallel
No. 3 Fault at sub 6—Bkrs C and D open, 2 lines paralleled
No. 4 Fault at sub 9—1 line only in use

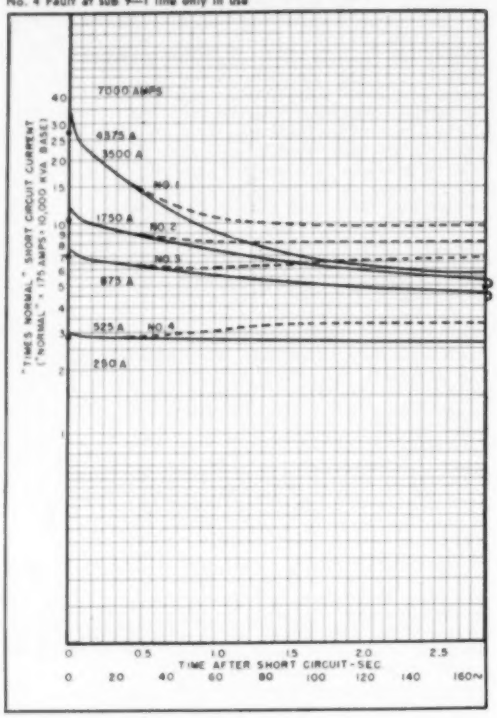


figure as though it were based on rated exciter voltage.

D. Exciter ceiling voltage in per cent of exciter rated voltage.

E. Generator-no-load, normal voltage excitation requirement with the generator rheostat all out, in per cent of exciter rated voltage.

If accurate data are not available an average figure of 50 per cent may be used. Approximately this amount of excitation will produce zero power factor short circuit current equal in magnitude to generator full load current.

F. Amount of excitation assumed to be on the generator at the moment when the short circuit starts, expressed as per cent of rated exciter voltage.

In the average case, the exciter operates at about 90 per cent of its rated voltage with the generator rheostat all out and full load on the machine. For the study from which the curves in Figs. 4 and 5 were taken, it was arbitrarily assumed that when the fault occurred the generators were carrying a partial load requiring that the exciters operate at 80 per cent rated voltage.

G. Generator open circuit time constant (T'_{do}).

H. Generator field time-constant (T'_d) for the particular fault condition being studied, i.e., with the generator armature (stator) connected to external reactance X_e.

Following is a step by step description of the required procedure for the construction of three-phase decrement curves:

1. Calculate the initial value of transient fault current for the given conditions of generation and fault location.

$$I_{e} = \frac{100}{X'_d + X_e} \text{ expressed in}$$

"times normal" base current.

2. Calculate Per cent a-c Volts that would be required "ahead" of generator synchronous reactance (X_d) in Fig. 2 to maintain the initial magnitude of transient fault current (Step 1). Per cent a-c Volts = (I_e from Step 1) $\times$ ($X_d + X_e$).

3. Calculate Per cent Exciter Volts required to produce the Per cent a-c Volts of Step 2. Use the design engineer's value of Per cent Exciter Volts required to produce OPF fault current equal to 100 per cent generator load current if available, otherwise use an average figure of 50 per cent (Condition E). If the 50 per cent average value is used, Equivalent Per cent Exciter Volts = Per cent a-c Volts $\times$ 0.50.

4. Calculate the time required for the exciter voltage to reach its ceiling starting from the value at which it was assumed to be when the fault started; i.e., with the generator at normal voltage no load, or carrying some assumed value of load at normal voltage.

$$\text{Time (secs.)} = \frac{\%\text{ Exciter Ceiling Voltage} - \%\text{ Exciter Voltage at Start}}{\%\text{ Volts per Second Exciter response}}$$

This method of determining the time required for the exciter voltage to reach its ceiling value is a close enough approximation.

5. Calculate the generator field time-constant (T'_d) for the particular fault location.

$$T'_d = \frac{(X'_d + X_e) \times T'_{do}}{X_d + X_e}$$

6. Now for the actual construction as illustrated in Fig. 6. Take a sheet of rectangular cross section paper and lay out Per cent Exciter Volts as ordinates and Time After Short

Circuit as abscissae. On the sheet thus prepared draw (1) a horizontal line representing Per cent Exciter Volts maintained unchanged at its assumed initial value without a voltage regulator in use, and (2) a slanting line representing Per cent Exciter Volts with the regulator in service. The ordinate of horizontal Line 1 is the assumed initial value of Per cent Exciter Volts, and the abscissae of its "starting point" is the the Time After Short Circuit equal to one generator field time constant (T'_d). Line 1 starts at this point, because it fulfills the requirements for the terminus of a line showing the slope of the first increment of the decrement curve. The slanting Line 2 coincides with Line 1 for the first 0.1 seconds, which is the assumed time required for an ordinary regulator and exciter combination to start raising the generator excitation. Line 2 then rises on a slope which will enable it to attain the per cent-exciter-ceiling-voltage ordinate in the time calculated from Step 4, whereupon it becomes horizontal. The shape of Line 2 is, of course, an approximation of the exciter behavior since the actual exciter voltage-response curve is normally steeper than that initially and then flattens out considerably as it approaches its ceiling.

7. Locate the point representing the initial symmetrical transient fault current from Step 1 using Per cent Equivalent Exciter volts from Step 3 as its ordinate and Zero-time as its abscissa.

8. Line up a straight-edge between the Initial Fault-current Point (Step 7) and the center (average)[2] of the first cross-section (time) division of the common portion of Lines 1 and 2, and draw a diagonal line across the first cross-section (time) division starting at the Initial-current point. This diagonal line will be the first segment of the decrement curve.

[2] The center (average) point is used to make allowance for the fact that the slope is changing throughout the period. However, the error introduced by using the beginning or end of the time division is nil for all practical purposes, if the time divisions are small, as should be the case.

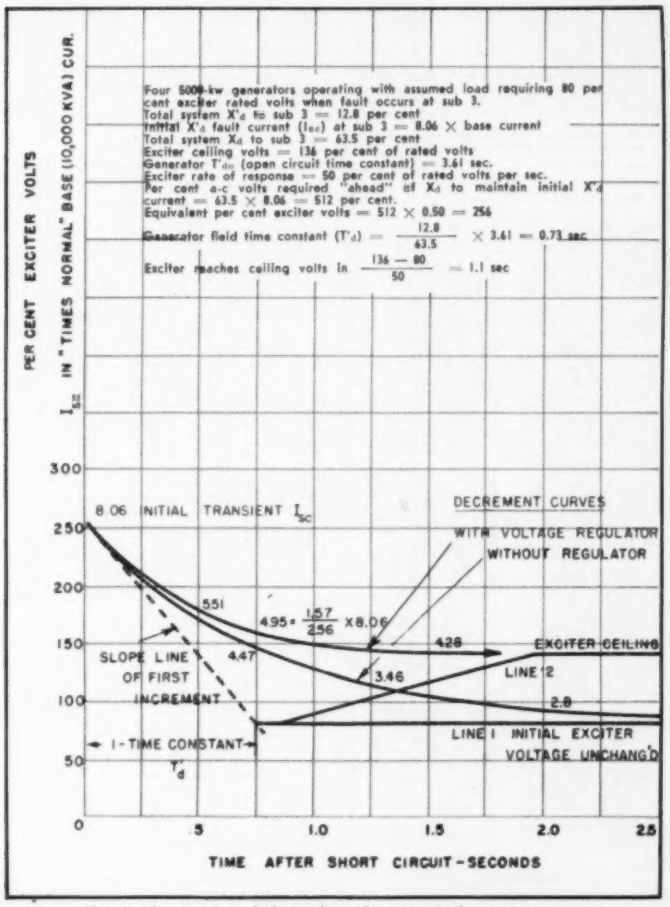

PER CENT EXCITER VOLTS
I_{sc} IN "TIMES NORMAL" BASE (10,000 KVA) CUR.
Four 5000-kw generators operating with assumed load requiring 80 per cent exciter rated volts when fault occurs at sub 3.
Total system X'd to sub 3 = 12.8 per cent
Initial X'd fault current (I_{sc}) at sub 3 = 8.06 × base current
Total system Xd to sub 3 = 63.5 per cent
Exciter ceiling volts = 136 per cent of rated volts
Generator T'do (open circuit time constant) = 3.61 sec.
Exciter rate of response = 50 per cent of rated volts per sec.
Per cent a-c volts required "ahead" of Xd to maintain initial X'd current = 63.5 × 8.06 = 512 per cent.
Equivalent per cent exciter volts = 512 × 0.50 = 256
Generator field time constant (T'd) = 12.8/63.5 × 3.61 = 0.73 sec
Exciter reaches ceiling volts in (136 − 80)/50 = 1.1 sec
8.06 INITIAL TRANSIENT I_{sc}
DECREMENT CURVES
WITH VOLTAGE REGULATOR
WITHOUT REGULATOR
551
4.95 = 157/256 X 8.06
4.47
3.46
428
2.8
EXCITER CEILING
LINE 2
SLOPE LINE OF FIRST INCREMENT
1-TIME CONSTANT T'd
LINE 1 INITIAL EXCITER VOLTAGE UNCHANG'D
300
250
200
150
100
50
0
.5
1.0
1.5
2.0
2.5
TIME AFTER SHORT CIRCUIT-SECONDS

Fig. 6. Construction of three phase short circuit decrement curves

9. Complete the curves by a continuation of Step 8 process, each time lining up the straight-edge on the right hand end of the previously drawn segment of the decrement curves and the center of successive time divisions in the two exciter-behavior lines. This procedure automatically maintains the one-time-constant (T'_d) difference between the abscissa of the beginning and end of the successive slope lines. Continue until the right hand end of the segmental curves thus drawn coincides with horizontal Line 1, and the end of the other curve coincides with the exciter-ceiling-voltage portion of Line 2, or an extension of it, except as explained below.

In those cases involving high-impedance, low-current faults as illustrated in Curve No. 4 of Figs. 4 and 5, where exciter-ceiling-voltage excitation is more than enough to restore normal voltage at the generator terminals (Fig. 2), the regulator will increase the generator excitation until the a-c voltage comes back to normal and then hold it there. When this condition prevails, the magnitude of the "final" or steady-state I_{sc} will be greater than that of the initial I_{sc}, because unit (normal) voltage is now being held at the generator terminals (Fig. 2) "ahead" of X_e alone, whereas initially it was held "ahead" of $X'_d + X_e$. Construction of the decrement curve to represent I_{sc} under this condition should be continued per Step 9 until $I_{sc} = \frac{100}{X_e}$.

The ordinate of the latter point (H) on the curve can be defined in terms of the ordinate (H_o) of the initial I_{sc}, and the relative magnitudes of the initial and final values of I_{sc}.

$$H = H_o \left(\frac{\text{final } I_{sc}}{\text{initial } I_{sc}} \right) =$$

$$H_o \left(\frac{\frac{100}{X_e}}{\frac{100}{X'_d + X_e}} \right) = H_o \left(\frac{X'_d + X_e}{X_e} \right)$$

Beyond this point (H) the curve is horizontal representing constant fault current.

10. The curves constructed as outlined above are in terms of Per cent Equivalent Exciter Volts and must be converted to "times normal" base current, which for any given point on a curve

$$= \frac{\text{"Times Normal" Initial } I_{sc} \times \text{Ordinate of Desired Point}}{\text{Ordinate of Starting Point}}$$

11. Now calculate the initial sub-transient-reactance fault current.

(Continued on page 118)

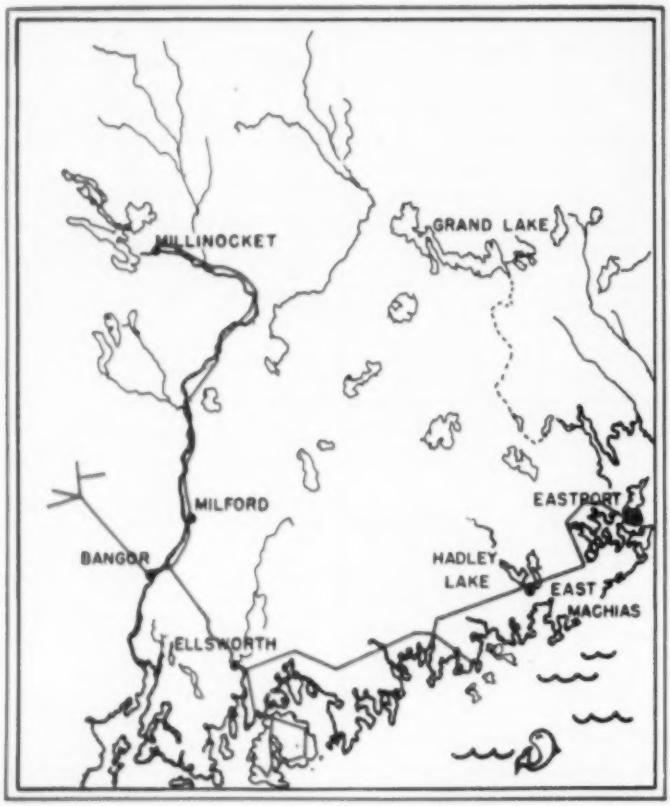
Diesels in a Hydro System

Bangor Hydro-Electric Company in Maine installs four Nordberg Diesel Engines in three of its power stations and is adding two more to insure continuity of electric service in adverse conditions. Located in three widely separated plants these engines also provide standby protection in the event of failure of the system's transmission lines

IN THE PAST YEAR, the Bangor Hydro-Electric Co., serving 145,000 people over a large area of Maine, installed four Nordberg Diesel engines totaling 5700 hp to augment its large hydro supply and insure continuation of the company's unbroken record of service to consumers under all conditions. Two more such units are on order for installation this winter. Located in three widely separated plants, the new engines also provide standby protection in the event of transmission line failure.

The prime movers chosen for all three plants are of the heavy-duty four-cycle type, each with seven cylinders, 16 in. bore and 22 in. stroke, developing 1425 hp at a moderate 327 rpm. To achieve this rating the engines are equipped with exhaust-driven turbo-chargers. Each Diesel drives directly a 3-phase, 60-cycle, 4160-v, 1000-kw generator with 20-kw belted exciter.

The Milford plant, about 15 miles north of Bangor on the Penobscot River, is integrated with the company's big hydro plant at that point, though a separate wing was built to house the two Diesels installed in this plant. Following the transmission line "down east" for about 90 miles, we find the East Machias plant on the East Machias River between Hadley Lake and the Ocean. Here again there is a hydro plant (900 kw under normal conditions) but the Diesel is housed in a separate building. Again following the transmission line north and east for some 30 miles, we come to Eastport, the easternmost city in the United States. Here the Diesel is the sole power producer.



Map showing the Bangor Hydro-Electric Co. Transmission System

Except for differences dictated by local conditions, accessory equipment and handling of fuel, lube and water are identical for the three plants. All have adequate fuel storage, four 20,000 gal tanks at Milford and three 20,000 gal tanks for each of the other stations. The No. 2 fuel is unloaded into the storage tanks by a motor-driven 125 gpm pump. At Milford it flows from storage by gravity through twin strainers and a meter into 300 gal day tanks in the engine room and is then drawn through duplex filters to the Diesel injection system by engine-driven gear pumps. There is a level gage with low-level alarm on each day tank. The only difference at East Machias and Eastport is that fuel is supplied to the day tanks by float-controlled motor-driven transfer pumps. A similar pump is available for use at Milford should the need arise.

Company engineers clearly recognize the importance of keeping lubricants free of contamination. Lube oil for each engine passes through twin strainers and duplex cartridge-type filters. In addition, each power unit is served by a purifier embodying an electric heater and Fuller's earth filtration elements. A motor-driven pump draws oil from the engine sump,

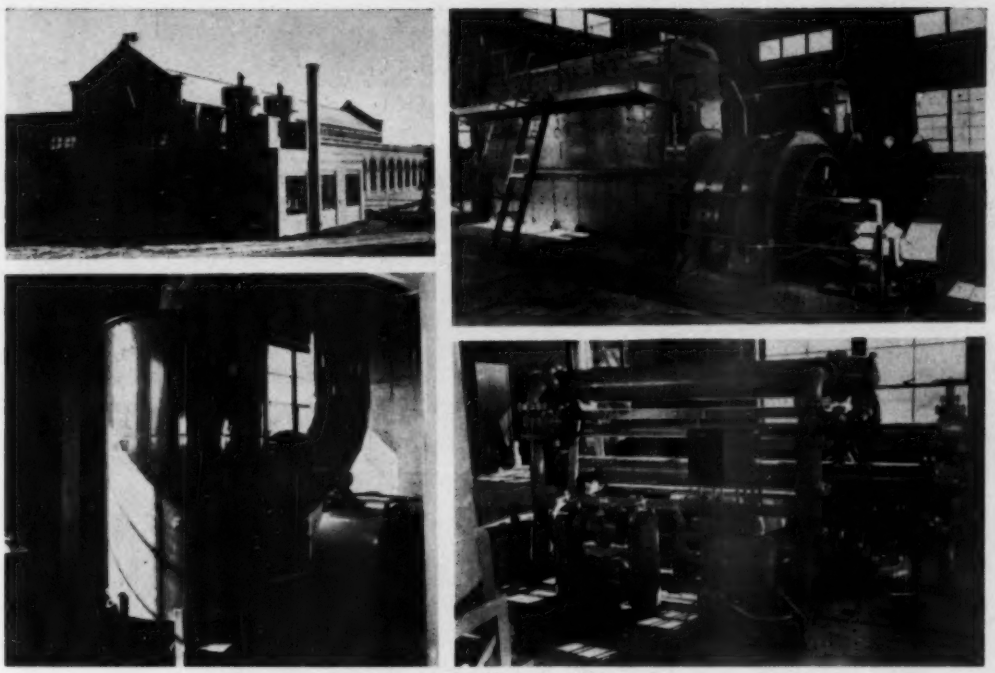


Fig. 1. The Plant at Milford

(A) An exterior view. The Milford plant is the largest of Bangor Hydroelectric's three diesel plants. The new building housing the diesels is in the foreground and the hydro plant and the Penobscot River are in the background. (B) The two 1425-hp diesels. (C) One of the Cycloil air filters. Air is drawn through an air cleaner. (D) Water pump, jacket, water cooler, lube oil cooler and strainer

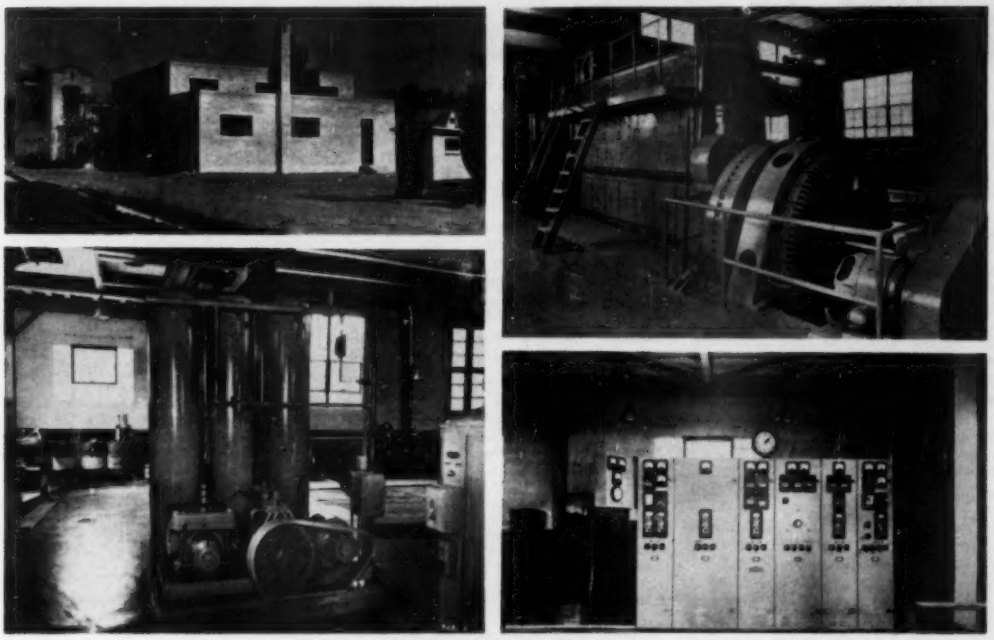
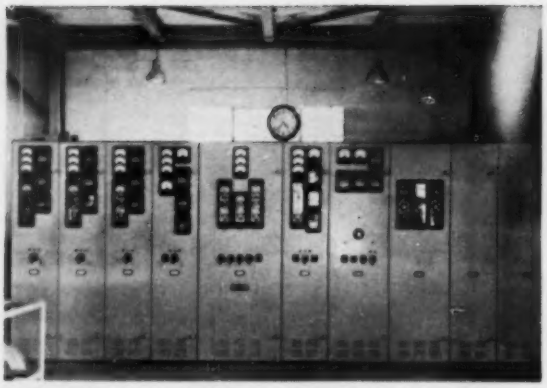
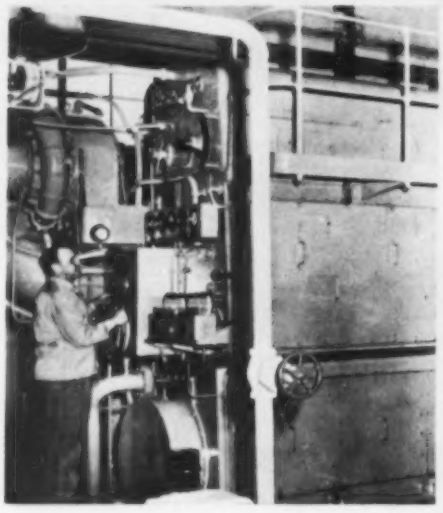


Fig. 2. The Diesel Plant at East Machias

(A) This new diesel plant was erected alongside the small hydro plant. (B) The 1425-hp diesel engine at East Machias (C) Starting air is supplied by a compressor which can be belted to either a motor or a gasoline engine. (D) The electrical control board





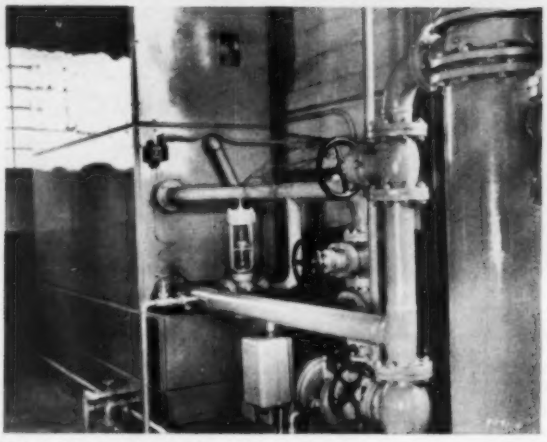


Fig. 3. The Diesel Plant at Eastport

(A) Bangor Hydroelectric's third new diesel plant is at Eastport, easternmost city in the U.S. Here too there is room for a second engine. (B) The main switchboard at Eastport. (C) Hollis Curtis, superintendent of the Eastport and East Machias plants at the controls of the Nordberg diesel at Eastport. (D) Jacket water for the engine is cooled in this evaporative cooler which has automatic thermostatic controls

puts it through the purifier and returns the clean oil to the sump. All bearings are lubricated by a pressure system which also serves to cool the pistons. An oil cooler is included in the circuit. A motor-driven auxiliary pump is used before starting and after shutting down the engine, and is started automatically if engine lube pressure drops. Cylinders are supplied with lube oil by separate force-feed lubricators.

The cooling water handling varies from plant to plant, though in every case a closed system is employed. At Milford and East Machias, jacket water is circulated through each engine and a separate heat exchanger by a 350 gpm motor-driven centrifugal pump. At Milford, raw water is drawn from the Penobscot River through twin strainers by a pair of motor-driven centrifugals, put through the heat exchangers and then wasted to the river. At East Machias, jacket water handling is the same but raw water is drawn from the hydro penstock, run through the heat exchanger and returned to the river. A motor-driven centrifugal pump also can be used to provide raw water. Eastport lacks the convenient and abundant source of fresh cooling water available to the other two plants and so it was decided to use an evaporative cooler. Water is circulated through

(Continued on page 100)

EQUIPMENT LISTING Milford, East Machias, Eastport

Engines: Nordberg Mfg. Co. Four 7-cylinder, 4-cycle, 16 by 22 in., 1425-hp Diesels operated at 327 rpm.
Generators: General Electric Co.
Governors: Woodward Governor Co.
Starting air compressors: Gardner-Denver
Water pumps: Allis-Chalmers
Evaporative cooler: Worthington Pump & Machinery Co.
Heat exchangers: Ross Heater & Mfg. Co., Inc.
Lubricating oils: Tycol. Tide Water Associated Oil Co. Teresso. Standard Oil Co.
Lube oil purifiers: Honan-Crane Corp.
Lube oil coolers: Ross Heater & Mfg. Co., Inc.
Lube oil filters: Wm. W. Nugent & Co., Inc.
Auxiliary lube pumps: Blackmer driven by G.E. motors
Cylinder lubricators: Manzel Brothers Co.
Fuel oil: No. 2 Tydol. Tide Water Associated Oil Co.
Fuel oil unloading pumps: Goulds
Fuel oil strainers: Elliott
Fuel oil meters: Buffalo-Niagara
Fuel oil level gages: Rochester magnetic "Magnetron." Rochester Mfg. Co., Inc.
Fuel transfer pumps: Blackmer
Fuel oil filters: Wm. W. Nugent & Co., Inc.
Air filters: Cycloil. American Air Filter Co.
Turbo-Chargers: Elliott-Buchi. The Elliott Co.
Exhaust silencers: Maxim Silencer Co.
Alarm systems: Viking
Switchboards: General Electric Co.
Pyrometers: Illinois Testing Laboratories, Inc.
Pressure gages: Lonergan
Batteries: Exide. Electric Storage Battery Co.
Outboard bearings: Dodge Mfg. Corp.
Expansion joints: Burgess-Manning Co.
Vibro isolators and snubbers: Korfund
Radio telephones: General Electric Co.

G-E'S *More Power to America* Special

On April 24th at Grand Central Station in New York, General Electric unveiled its special ten-car train and locomotive carrying the biggest electrical display kit ever built. New York was the first lap of a nation-wide tour that will bring the exhibit of producer goods for industry to some 150 key industrial centers during 1950 and 1951

FOR SEVERAL CENTURIES a battle has raged among philosophers over an interesting question, one thought to have been first suggested by Bishop Berkeley: If a tree falls deep in the heart of the Siberian wasteland, where no one can hear it fall, does it really make a sound? Or does it only make a sound when someone *hears* it?

Quite obviously, this a question of semantics, but leaving the semantic and metaphysical aspects of the question up to the philosophers, General Electric has arrived at the only conclusion satisfactory for business purposes, namely, unless someone hears about an event, it may as well not have happened.

In the past ten years, the engineers at the General Electric Co. have spawned about 8000 inventions —roughly two a day, year in and year out. In addition, they have produced untold other ideas for product improvement, combination, and application.

But, like trees falling in the Siberian forest, these ideas mean *nothing* to the world *unless* and until someone hears about them.

The purpose of the More Power to America Special is to see that 2000 of General Electric's finest mid-century ideas shall not lie useless but shall be put to work for a more productive America. And the only way to do this, as any Fuller brush-man can tell you, is for the company with a better mousetrap or brush or turbine to sell them by beating paths to its customers doors.

This, in G-E's case, is a bit difficult and complicated because of the complexity of the highly engineered products and systems that General Electric's apparatus department has for sale. A salesman cannot simply toss a gas turbine or a steel-mill drive into the back of his car when he goes to call.

It was to overcome this limitation that the General Electric Company decided several years ago to build a train in which to arrange a display of products and developments which could be run around the country and be displayed in the Nation's industrial centers. This idea today has its embodiment in the G-E More Power to America Special.

This ten-car train complete with its diesel-electric locomotive represents the first attempt to display in one series of related exhibits all the apparatus to create electric power, to distribute it, and put it to work in a variety of productive ways. Likewise, it represents the pioneer attempt to take such a display on a tour of the entire United States for inspection by those who have a hand in using these producer goods to provide the many needs of the nation.

One other unusual *first* feature—The More Power to America Special represents the first time a display of this kind has been installed in what is virtually a tunnel, 9½ ft wide and 1000 ft long. These peculiar space requirements imposed many problems that were met in planning and executing the exhibit part of the project.

The specifications worked out for the exhibits took into consideration such factors as size, weight, center of gravity, shock resistance, and electric power requirements. The exhibits had to be secured so they would not be affected by train movement. Weight distribution had to be carefully calculated so the cars would be easily balanced. Planning for good traffic flow was essential.

Fig. 1. J. W. Belanger (left), Assistant General Manager of G-E's Electrical Apparatus Department, and E. E. Parker, Manager of Engineering for the Department's Turbine Division, examine one of the major exhibits in the Power Generation section. Actual turbine components are shown in the foreground. Buttons adjacent to these components enable visitors to light up on transparent bas relief in the background, the sections of the turbine where the components are located

The train consists of a modern diesel-electric locomotive and ten stainless steel passenger coaches housing exhibits and reception facilities. The locomotive is an American Locomotive Co-General Electric two unit 4500-hp road locomotive. It is powered by two 16-cylinder 2250-hp supercharged Alco Vee type diesels and is geared for operation at 92 miles per hr.

The ten new stainless steel cars are standard passenger cars built to Chicago, Rock Island & Pacific specifications by the Pullman Standard Car Mfg. Co. Arrangements have been made with the Rock Island for the purchase of the cars upon completion of the tour which will take about two years. Each car is equipped with its own undercar G-E diesel-driven power plants. These 30-kw units are mounted beneath each of the streamliners' ten cars and four additional units are installed in a section of the bagagge dormitory car to supply additional power required by some exhibits. The chief advantage of this type of equipment is the elimination of the load on the locomotive produced by axial-driven generators. Designed so as to allow unrestricted movement on any of the nation's railroads, each power plant consists of a 4-cycle Buda engine driving a 220-v, 3-phase, 60-

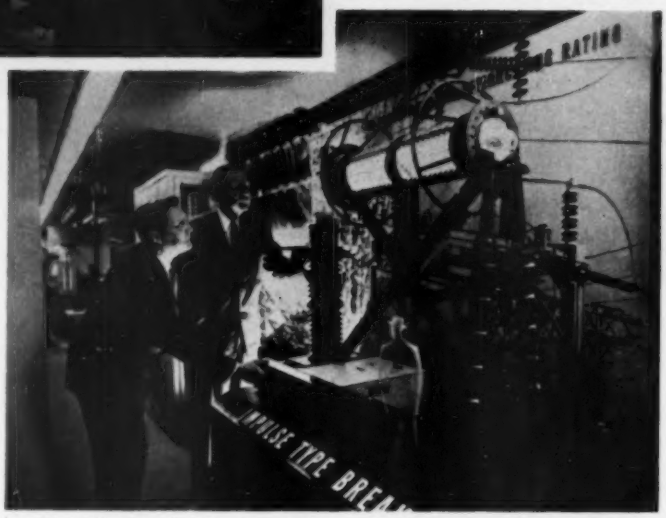


Fig. 2. H. V. Erben (right), vice president and general manager of G-E's Apparatus Department, and J. S. Smith, manager of the Department's Advertising and Sales promotion Divisions, operate a model of a huge 230-kv breaker in the Power Generation Section

Fig. 3. K. H. Runkle, manager of the Industrial Divisions, Apparatus Department, examines one of the operating drive systems in the Drives and Controls section. This consists of the continuous moving of a 21-ft long steel strip, six in. wide over a series of rollers

Fig. 4. E. A. Green, General Electric Control Divisions Sales Manager, operates one of the control exhibits. Electronic color and cut-off register controls are shown in this display, which demonstrates the principles by which four or five colors are printed

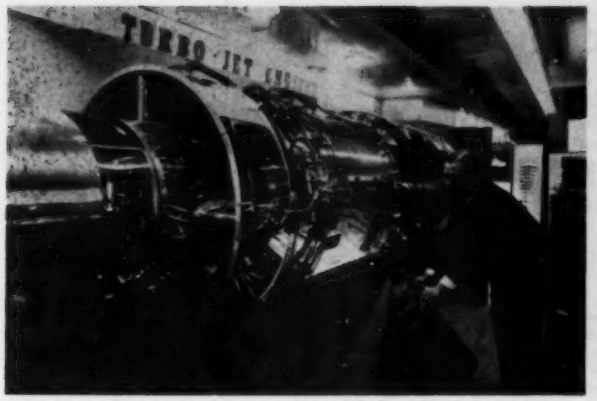


Fig. 5. H. P. Bish, manager of the G-E Aircraft, Federal and Marine Divisions, Apparatus Department inspects a full-size cutaway model of the J-47 turbojet engine. It was this engine which, in a fighter plane in 1948, set the world's speed record of more than 670 miles per hour

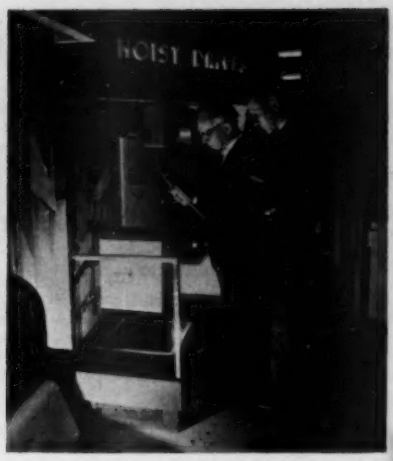


Fig. 6. C. H. Lang (left), vice president in charge of sales for the Apparatus Department, and C. P. Fisher Jr., Manager of the Apparatus Exhibit Train Division, spot a dummy load in the Materials Handling Section of the train

cycle alternator. The alternator, with an ultra-high-speed amplidyne exciter and static-type regulator has a maximum gross rating of 33.8 kva. The total weight of the diesel driven equipment is less than that of the conventional axel-driven generator with its attendent batteries, cable, control and drive unit. Maintenance of the new G-E power plant is facilitated by a hinged mounting arrangement which permits it to be swung out of its housing and out from beneath the car. Engine water is cooled by a separately-mounted radiator which is blown by a motor-driven, propeller-type blower. All of the power plants are designed to operate in parallel and the alternators were designed to eliminate the need for synchronizing equipment to parallel the sets. Another major advantage of the new type power plant is the fact that it makes available a large supply of potential heat in both the engine jacket water and the engine exhaust, in addition to supplying about 20-kw of electric heat. Efficient car heating equipment will be able to recover about 18 kw of exhaust heat and 25 kw of waste heat from the jacket water.

The arrangement of the train is shown in the sketch below. There is a planned logical order to the exhibits. Visitors will first see equipment for producing electric power, then the equipment for transmitting it, then the techniques for putting the power to profitable use. Most of the exhibits go through an operating cycle automatically or can be energized by visitors. Where size and weight permit the actual equipment is displayed. In the case of larger equipment, turbine generators, transformers circuit breakers and the like scale models or other representations are used.

The More Power to America Special will visit about 150 industry centers in the U. S. this year and next. Visitors will be confined to industrial, utility and transportation and those responsible for civic improvements. It is estimated that visitors will average about two hours in going through the train.

The train represents the combined work of many General Electric people in engineering, sales, manufacturing, and research. Responsibility for the production of the entire project was centered in the Advertising and Sales Promotion Divisions, whose resources were devoted to the job for more than a year. Products exhibited on the train came from more than a score of G-E plants. Six display houses took part in building the exhibits for the train.

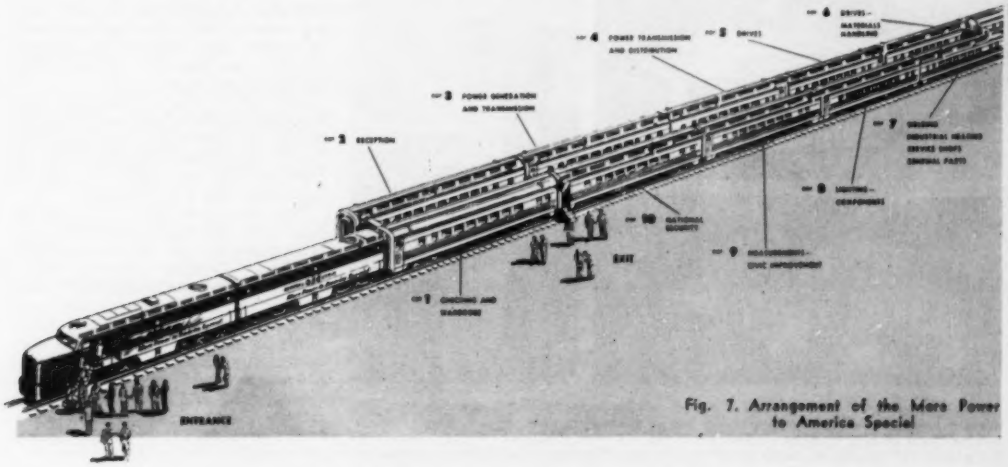


Fig. 7. Arrangement of the More Power to America Special

Power Cost Practically Zero

Small hydro plant of unusual design and construction supplies power and light to French-Canadian saw mill and owner's home at practically no cost except initial ingenuity and skill in building plant

By E. NESBITT

AN INTERESTING METHOD of harnessing water-power from a small stream, to operate a small electric generator for mill and house lighting, and to turn the drive shaft running four ripsaws and a Berlin planer is illustrated in the accompanying photographs taken near Quebec City, Canada.

In this instance the French-Canadian owner, whose mill and home are located about half a mile from the shore of the St. Lawrence River, on the side of a hill, has borrowed an idea he obtained from a German engineer. This involves the use of a water tower in which is installed a horizontal wooden paddlewheel.

The stream, which comes from nearby mountains, has a steady flow most of the year. To operate the wheel, however, the water must have a head of at least 20 ft and that is where the water tower comes in. The water tower has a vertical shaft and a horizontal wooden paddle wheel revolving at the bottom. The tower is about 30 ft high. The water level remains fairly constant at the 20 ft level inside the tower.

Water is piped from a small dam, a distance of about 150 ft north of the mill building, and 22 ft above it, by means of a galvanized iron pipe about 18 in. in diameter.

This flume empties into the 30-ft tower or tank, about 22 ft above the ground. The inside measurement of the square tank is about 7 by 7 ft.

A horizontal water wheel, 6 ft in diameter, and built of wood, is mounted at the bottom and inside of the tank, on a long vertical steel shaft 4 in. in diameter. This shaft is connected at the top of the tower to the main drive shaft by means of two large wooden bevel gears. The small gear is about 2 ft at its largest diameter, and the larger gear about 6 ft in diameter. Both gears are about 12 in. thick and have replaceable hardwood teeth.

The wooden vanes on the water wheel are about 1⅛ in. square. The outlet from the bottom of the tank is located at one side, or corner, and measures about 18 in. square. It is the force of the pull, from the 20 ft head of water rushing out this off-center outlet, which pulls the big water wheel around, and turns the gears connecting to the main drive shaft.

The main shaft is belted to the ripsaws and planers and to a small electric generator, which supplies power to the mill lighting system, and to the owner's nearby home, at a cost of practically nothing.

Although this mill has been operating for several years, through winter and summer, at all temperatures from zero to ninety above, the flow of the stream is seldom cut off by ice or lack of rain. However, to keep the electric generator running in emergencies an auxiliary gasoline engine from an old automobile is kept in readiness should the water supply fail. This very seldom occurs. Maintenance costs are negligible.

Fig. 4. The 51-in. ripsaw operated by water power. This is one of four saws

The many advantages of water power for operating a small sawmill may be somewhat obvious. Most other small suburban or rural sawmills pay a high rate for electric or steam power and must include such costs in the price of dressed lumber. But this is definitely not the case with U. Belanger & Fils. Ltée., (U. Baker & Sons, Ltd.), who have been able to sell their lumber at considerably less per board foot than any other mill in the district. And, of course, the house and mill lighting costs nothing even if the lights remain on all night.

Fig. 5. The large wooden bevel gears at the top of the turbine's steel shaft

This tower type of water turbine is comparatively simple to construct, except for the huge wooden gears. But if a gear tooth breaks, it can be quickly replaced with a strip of hardwood and a few bolts.

The way he explains it, it sounds easy. But the task of building the huge gears is a lost art in most rural districts. Perhaps because many French-Canadians are skillful woodcarvers and carpenters, the gear problem did not present any great difficulty in this instance. But how many American farmers or mill operators would care to tackle the construction and designing job is a matter of some speculation. Many could do it. For those, power would be cheap.

Fig. 1. (Above Left) U. Belanger & Fils, Ltée lumber mill at Gifford, near Quebec City, showing water intake pipe leading to the top of the water tower. Fig. 2. (Right) Water turbine tower or tank showing discharge into the old stream channel. Fig. 3. Below left) The stream that supplies the water power and the dam. The intake pipe is at the extreme left

The PRACTICAL ENGINEER and ELECTRICIAN

ANDREW W. KRAMER, EDITOR

★

IT EASILY TAKES FIRE

PETROLEUM. A fluid bitumen, of somewhat greater consistence than naphtha, of a black, brown, or sometimes dingy green colour. By exposure to the air, it assumes the consistence of tar, and is then called *mineral tar*. This substance exudes spontaneously from the earth, or from clefts of rocks, and is found in nearly all countries. Near Rangoon, in Pegu, there are several hundred wells of petroleum, which are carefully preserved and yield annually 400,000 hogsheads. At Colebrook-dale in Shropshire, there is a considerable spring of petroleum, from which large iron pipes are employed to convey it into pits sunk to receive it. From these pits it is conveyed into caldrons, in which it is boiled until it attains the consistence of pitch. Since the first discovery of this substance, three different springs of it have broken out: one of these is near the celebrated iron bridge, and the fluid which issues from it is almost pellucid, but, at the same time, thicker than treacle. Petroleum easily takes fire, and in burning yields a strong, sharp, and somewhat unpleasant odour; a thick and disagreeable smoke. In cold weather it congeals in the open air. It is used instead of oil for lamps in some places; also is supposed to check and prevent the future ravages of the worm upon the bottoms of ships coated with it.

—The Engineers and Mechanics Encyclopedia, comprehending Practical Illustrations of The Machinery and Processes employed in every description of manufacture of the British Empire. Published, London, 1836.

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THE PRACTICAL ENGINEER AND ELECTRICIAN

Strictly MELARKEY

Oscar, the Gas Works Owl, sounds dire warning but gets off the straight and narrow path himself, thereby teaching another lesson

By JOHN RAVEN

IN THE GAS WORKS where anything can happen, I don't know why the visiting Rajah from India or somewhere had to drop his teeth into the condenser intake on that particular afternoon. There I was, already worrying my head off because for three days Oscar the Gas Works Owl had been attempting to give me a portentous warning, and all I could decipher from his hen-scratchings were frightening words and phrases like "terrible" and "take warnin b4 its 2 late," and one ominous reference to an "elixr of darknes." Each message ended in a wild unreadable scrawl, as though

The Boss exploded in my face

some malignant force had indeed grabbed Oscar by the tail, and dragged him away before he could complete his warning.

This afternoon, I'd just decided to go down to the water front and ask the advice of Honest Melarkey, who is a religious man and knows all the verses in the Bible, when the telephone rang and the Boss exploded in my face right over the wire.

"John," he bellowed. "Shut down Power House No. 1 quick. Before the Rajah's teeth get sucked into the condenser. And get me a diver. You hear? Call the Divers' Union. Call the Pilots' Association. Call the shipyard. The Rajah's got to make a dinner speech, and if we don't get his teeth in half an hour, you're fired. Understand?"

"Boss," I said soothingly, "Stop worrying. We've got a works diver. His name's Melarkey. He'll get the Rajah's teeth in half—"

"Melarkey!" the phone almost jumped out of my hand. "Melarkey's fired! F-i-r-e-d, fired! He's an idiot. Now get me a diver!"

The telephone banged, and suddenly I was very conscious of the ticking of the big clock on my office wall. I could see its hands moving steadily at the business of pushing me right off the payroll. Sometimes the Boss is quite impetuous.

I started calling. Twenty minutes and fifteen telephone calls later, Power House No. 1 was still shut down, half the gas works was likewise, and there was no diver. Tomorrow maybe, but today was too late. All the divers were elsewhere, doing this and that, and couldn't be bothered by the Rajah's teeth.

When the Boss called up to check on my progress, all the lights were out, and three department heads were screaming at me across the desk, and wanting to scalp me on the spot.

"Boss," I said, "Don't you think we'd better tie in with the electric company's emergency service for light and power?"

"John," he hollered tragically, "Don't you know that's treason? This is the gas works and we got to protect our reputation. Either get a diver in ten minutes or get out."

Bang went the telephone. I looked at the department heads across my desk who had heard everything.

"Well," said one, "why don't you do as he says? Get a diver."

I wondered if maybe diving wasn't too difficult and I could do it myself. Thinking about it gave me an idea:

It would be treason

why not send Melarkey down in disguise? Once the helmet was on, even the Boss couldn't tell who was inside it.

The clock said I had eight minutes to find Melarkey. I grabbed up a pair of dark sun glasses for disguising him, and set out full speed to the pump house where I hoped to find Honest Melarkey still present and packing up his things. Instead I found Horseface McGinty the oiler, squirting oil into a pump bearing and obviously alone.

"Honest Melarkey?" said Horseface, "He left here twenty minutes ago without sayin' where he was goin'. He was feelin' mighty bad, mighty bad, about bein' fired."

I saw the pump house clock cutting my time down to six minutes and I said desperately:

"Horseface, did you ever dive?"

"Not me," said Horseface hurriedly. "I'd quit first."

Since Honest Melarkey had to go through the timekeeper's office at

Sitting at the counter with a row of beer mugs lined up in front of him

the gate house in order to leave the gas works, I galloped there next.

"Sure he's been here," said Joe Dugan the timekeeper. "Checked out ten minutes ago. Feelin' mighty bad, too, about bein' fired."

"Did he say where he was going?"

"That he did," said Joe. He scratched his grizzled head. "But danged if I can remember where. I can give you his home address."

"No time," I said, "for that."

I was just about to tell Joe to check me out too, when his assistant, Little Joe the Clerk, yelled:

"John, you lookin' for Honest Melarkey? I saw him across the street in the Gas House Grille not five minutes ago, gettin' drunk on beer."

The big time clock said I had three minutes as I bolted across the street, right through the traffic. And sure enough, there was Honest Melarkey, sitting on a stool at the counter, and with a row of beer mugs lined up in front of him.

He had his back to me, and as there was no time for the amenities, I just reached over his shoulder and slapped the sun glasses on his nose.

"Quick, Honest Melarkey," I said, "put down your beer and come with me. These sun glasses disguise you just like Hollywood. After you've made one dive we'll both be back on the payroll. O.K.?"

Honest Melarkey hung his head and I had the peculiar feeling he was crying into his beer.

"It can't be done, John," he said mournfully. "I already made one dive. The bottom of that river is black as the rat holes of Hell, and when I come up I told the Big Bushwah hisself I wouldn't dive no more except I could carry a lighted candle in my hand to see by. He fired me, but what Honest Melarkey speaks is true as iron. No lighted candle, no dive. I have spoke."

"But Honest Melarkey, you know a lighted candle won't burn under water. It's impossible."

"That's why I said it," ano there was a sob in his voice. "I wish I hadn't. John I have yielded to the Devil. Look—"

He turned around and so help me, I thought I was looking at the face of a horse showing a permanent sneer. I never saw a bigger set of buck teeth on anything smaller than a mule. The meaning of it hit me all at once.

"Honest Melarkey," I gasped in awe, "You're wearing the Rajah's teeth!"

He nodded sorrowfully, and those big molars chomped up and down as though they were working on a bale of hay.

"John, the Devil grabbed me there at the bottom of the river when I found them teeth and he said, 'Honest Melarkey, you need them chawers worse'n the Rajah. He's got money to buy chawers and you ain't. Keep 'em.' So I thunk up the candle idea as an excuse for not divin' no more, and I kept 'em."

I looked at those big guillotines sliding up and down between me and my job and I said:

"But Honest Melarkey, you've got to give them back. Keeping them is dishonest."

"Course it's dishonest," he said, "and Honest Melarkey don't do nothin' dishonest. Besides they don't fit. But I give my word about the candle, and who ever heard of a candle stayin' lit under water? How can I dive and find 'em honest-like?"

"Whoooooo," said a quavering voice from down the counter and I looked around to give a cold eye to any character who could make flippant remarks at a time like this. But what I saw was one of those big glass jars that usually are stuffed with peanut butter sandwiches. It was upside down on the counter and instead of sandwiches it was enclosing a little feathered somebody with big yellow eyes. One of those eyes winked at me through the glass.

"Good Heavens!" said I, "It's Oscar!"

"Oscar?" says Honest Melarkey, "That's nothin' but a little old screech owl. He's boiled, on beer. Been a-comin' around for three days lappin' up all the spilled beer he could find. They caught him just afore you come in, and slapped him under the jar."

Oscar gave me another drunken wink, and right away I knew the reason for those wild notes: he hadn't been sober for three days. Then he opened his beak and gave a kind of gasp as though he was short of breath and all at once more light hit me.

"Honest Melarkey," I yelled grab-

"Good Heavens! It's Oscar!"

ing the jar off Oscar, who flew promptly, but tipsily out the front door, "Pick up your candle. You can light it, and carry it down to the bottom of the river under that jar. If it holds enough air for an owl, it will keep a candle lighted too. Come on, Honest Melarkey, we're going back on the payroll!"

Right now both the Boss and Honest Melarkey think I'm more bright than somewhat. As for Oscar he wrote me a note thusly:

njuneers n owls shudnt get boild if they want 2 stay alive its the wagn 4 me from now on urs n gratitud oscar th gas wrks owl hoo cs al n somtims nos al p s i dont feel good enuf 4 any mice 2day.

Heat of Combustion of Fuel Oils

In this fourth article on the characteristics, Mr. Schmidt discusses the factors that determine the heating value of fuel oils and presents data useful in evaluating the heating value of fuel oils

By PAUL F. SCHMIDT
Allied Oil Company, Inc., Cleveland, Ohio

WHEN PURCHASING and burning fuel oil, the primary object and purpose is heat. Other specifications are incidental when compared to the amount of heat that an oil well will produce. Different grades and types of fuel oils will liberate various amounts of heat, which should be known and understood by the consumer. Buying the wrong kind of oil, and inefficient methods of handling it, will result in large amounts of heat loss, that should otherwise be used for an economical operation.

Meaning of Heat Value

One of the most outstanding features which an oil has over other types of fuels is the high concentration of heat per unit quantity. The thermal value of a fuel of any type is the amount of heat liberated by its complete combustion. This value is called the Btu content, which means British thermal unit. This British thermal unit is the heat required to raise the temperature of 1 lb of water, 1 degree Fahrenheit.

The heat of combustion of petroleum oils is determined by means of the oxygen bomb calorimeter. The bomb, as it is called, is a metallic cylinder, approximately 7 in. high, 3½ in. in diameter, and with ½ in. thick walls. A weighed quantity of oil is completely burned in the presence of oxygen, and the heat given off from the combustion is absorbed by a known volume of water in which the bomb is immersed. The amount of heat is obtained by determining the temperature rise of the water, and then converting to Btu.

There are two different heating values for any oil, namely, total or

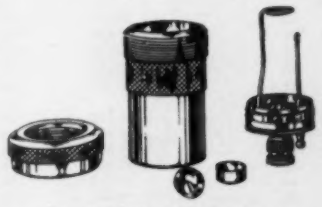


Fig. 1. The Parr Oxygen Bomb

high heating value, and net or low heating value. The only difference between these heating values, is that in the total heating value, the condensation of water vapor formed in the combustion, is included. When determining net heating value, the water remains in the gaseous state, and not condensed.

The Btu value for total heat will be higher by approximately 8400-8500 heat units per gallon, than the net Btu value, and about 1000 more Btu per lb. This large difference can be easily understood, when it is remembered that when one pound of water is condensed at 60 deg. it will evolve 1058 Btu. Depending upon the percentage of hydrogen present in an oil, there will be from 7 to 9 lb of water produced for each gallon of oil burned. Both values are used, but the net or low heating value is the one more closely related to the heat produced under actual combustion, as the water usually leaves the combustion chamber in the gaseous state.

As the equipment and apparatus used to determine the Btu value is expensive and not generally available, a correlation between the gravity of an oil, and its Btu content, has been worked out. These values will vary with the different fuel oils as will be explained later, but for all parctical purposes, their accuracy is close enough.

Shown in the accompanying table, are the Btu values per pound, and per gallon, corresponding to the API (American Petroleum Institute) gravity at 60 F.

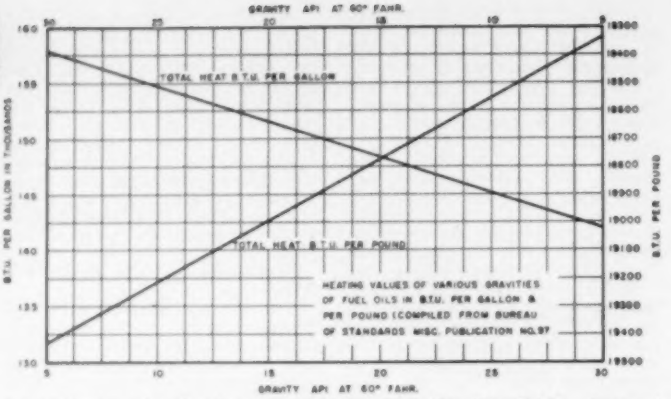

GRAVITY API AT 60° FAHR.
TOTAL HEAT B.T.U. PER GALLON
TOTAL HEAT B.T.U. PER POUND
HEATING VALUES OF VARIOUS GRAVITIES OF FUEL OILS IN B.T.U. PER GALLON & PER POUND (COMPILED FROM BUREAU OF STANDARDS MISC. PUBLICATION NO. 97
BTU PER GALLON IN THOUSANDS
BTU PER POUND
GRAVITY API AT 60° FAHR.

Fig. 2. Heating value of various gravities of Fuel Oil in Btu. *(Compiled from Bureau of Standards Misc. Publication No. 97.)*

Heats of Combustion of Fuel Oils

Gravity API	Total Heat of Combustion Btu per lb	Total Heat of Combustion Btu per Gal	Net Heat of Combustion Btu per lb	Net Heat of Combustion Btu per Gal
10	18,540	154,600	17,540	146,200
11	18,590	153,900	17,580	145,600
12	18,640	153,300	17,620	144,900
13	18,690	152,600	17,670	144,200
14	18,740	152,000	17,710	143,600
15	18,790	151,300	17,750	142,900
16	18,840	150,700	17,790	142,300
17	18,890	150,000	17,820	141,600
18	18,930	149,400	17,860	140,900
19	18,980	148,800	17,900	140,300
20	19,020	148,100	17,930	139,600
21	19,060	147,500	17,960	139,000
22	19,110	146,800	18,000	138,300
23	19,150	146,200	18,030	137,700
24	19,190	145,600	18,070	137,100
25	19,230	145,000	18,100	136,400
26	19,270	144,300	18,130	135,800
27	19,310	143,700	18,160	135,200
28	19,350	143,100	18,190	134,600
29	19,380	142,500	18,220	133,900
30	19,420	141,800	18,250	133,300
31	19,450	141,200	18,280	132,700
32	19,490	140,600	18,310	132,100
33	19,520	140,000	18,330	131,500
34	19,560	139,400	18,360	130,900
35	19,590	138,800	18,390	130,300
36	19,620	138,200	18,410	129,700
37	19,650	137,600	18,430	129,100
38	19,680	137,800	18,460	128,500
39	19,720	136,400	18,480	127,900
40	19,750	135,800	18,510	127,300
41	19,780	135,200	18,530	126,700
42	19,810	134,700	18,560	126,200
43	19,830	134,100	18,580	125,600
44	19,860	133,500	18,600	125,000
45	19,890	132,900	18,620	124,400

The data in this table were taken from the Bureau of Standards Misc. Publication No. 97.

Btu Change with Per cent of Hydrogen

When the gravity of fuel oils increase, or becomes lighter, the Btu per gallon decreases, but the Btu per lb will increase. Also as the gravity increases, so does the percentage of hydrogen. As more hydrogen is present, more Btu per lb are obtained, but as the weight per gallon increases at a faster rate than the Btu per lb, the Btu per gallon for the higher gravity oils, is less than for lower gravity oils.

When one pound of hydrogen is completely burned, there are about 62,000 heat units produced, while if one pound of carbon is burned, only 14,600 Btu are liberated. You will easily realize, that an oil with more hydrogen, must necessarily produce more heat. As an illustration, the following examples are shown.

Gravity API	Approx. Per cent Hydrogen	Btu per lb	Btu per gal
10	11.00	18,540	154,600
20	11.99	19,020	148,100
30	12.86	19,420	141,800
40	13.62	19,750	135,800

Fuel oils are usually purchased and sold on a volume basis. Therefore oils with a lower gravity will give the consumer more heat per gallon.

Btu Content of Different Type Oils

Most cracked oils will have a lower gravity than straight run oils, thus giving more Btu, which is one very distinct and important advantage. To illustrate the difference, let us take two oils, a No. 2 and a No. 5. Both of these type oils are easily combustible in different industrial burners, so it can readily be seen, which oil would be the most economical to use.

	API Gravity	Total Btu Value, per gallon
No. 2 straight run oil	38	137,000
No. 2 Cracked oil	30	141,800
No. 5 straight run oil	22	146,800
No. 5 cracked oil	13	152,600

The cracked or low gravity No. 2

oil, will have 4800 Btu more, than the straight run, or high gravity No. 2. The No. 5 cracked oil will show 5,800 Btu more, than the straight run No. 5. Multiply these differences by a tank car of 10,000 gallons, and you will have some fancy figures. These calculations will show 48,000,000 Btu more in a tank car of the 30 gravity No. 2 oil, which is equivalent to 350 additional gallons. In the tank car of the 13 gravity No. 5 oil, there will be 58,000,000 Btu more, equaling 327 additional gallons.

This little comparison will serve to give a general knowledge of the various heating values of different types of fuel oils, so as to make possible, increased savings by purchasing, and using a more economical fuel oil.

Theoretically, two oils having the same gravity, should have the same Btu content, but this is not true in every case. Variations in the heat values, can be due to any of the following factors. These factors may be small and somewhat insignificant, but nevertheless will decrease the heat content.

1. Difference in percentage of carbon and hydrogen present, will cause variations, as the more hydrogen an oil has the more heat it will produce.

2. The type and percentage of the various hydrocarbons in an oil, will cause differences, as the parraffinic, naphthenic, olefinic, and aromatic hydrocarbons possess different heating values.

(Continued on page 88)

Fig. 3. Don't use a cold chisel and hammer to free the inner ring from the shaft

Don't Abuse That Ball Bearing

Practical hints of value to every maintenance man

WHEN BALL bearings must be removed for one purpose or another much expense, patience and trying delays can be eliminated if just a few precautions are taken. Remember that the tight element of a ball bearing is on the rotating member of a machine and as the shaft is usually part of this rotating member, the inner race will be the tight one. These pointers on ball bearing are limited to removing ball

Bearings of this nature are simple drives consisting of an inner and outer race between which are placed a sufficient number of accurately ground steel balls to keep the two races evenly spaced with relation to each other, and with sufficient clearance to prevent binding. Since it is a self contained unit, we are prone to forget the damage that can be done through careless-

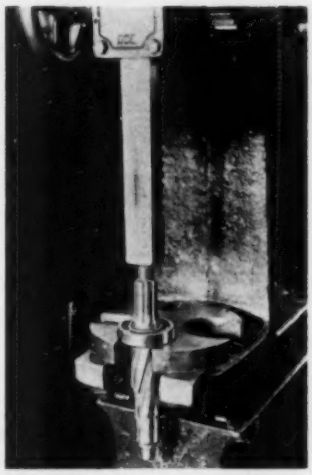


Fig. 2. Don't press bearing off shaft while it is supported by the outer race only

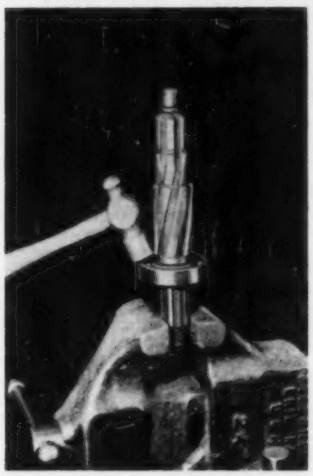


Fig. 1. Don't hammer on the outer race

ness when it must be removed from a shaft.

The tools ordinarily required for this operation are simple, and there is no reason why makeshift methods should be tolerated. For most cases a hammer or hand press and drift pipe can be used. In special cases, when there is interference in back of the bearing such as a high shoulder or gear, a suitable puller should be provided. The following gives the things to be avoided and the right procedure in removing ball bearings.

1. Don't use a hammer on the outer race. It will cause the balls to dent the surfaces of the race grooves. It may also damage the shaft.

2. Don't press bearing off shaft while it is supported by the outer race only. If this is the only method that can be used, considerable care must be used to see that the bearing is square with the die plate.

3. Don't use a cold chisel and hammer to free the inner ring from the shaft. This will always damage the shaft shoulder or bearing seat on the shaft through cocking.

4. Removing ball bearings by pressure on the outer race is always dangerous, and when it is necessary, great care must be exercised to prevent dinting of the races.

The Right Way to Remove Ball Bearings

1. Above all else, make sure that all tools used in removing bearings are clean. After bearing has been taken

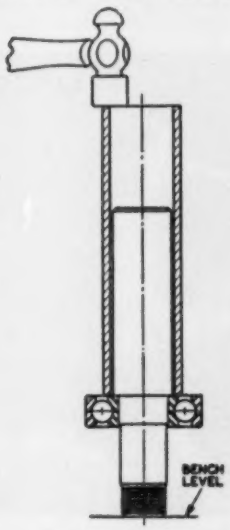


Fig. 4. The right way to remove ball bearings

off the shaft, keep it in a clean place, and before replacing on shaft, thoroughly clean, inspect for defects and pack with the proper lubricant. Westinghouse 8-ounce tube, S#1360876 will produce good results.

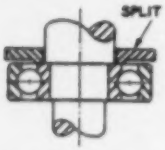


Fig. 5. Showing use of split ring

2. Where there is sufficient surface of the inner race exposed so that a pipe can be slipped over the shaft, the procedure shown can be used. A plate on top of the pipe will give more even impact.
3. If there is a recess in the shaft between the bearing and spline or gear, a split ring can be used to obtain more pressure surface on the inner race. If shaft has a shoulder below the bearing, rest the shoulder on the jaws of the vise and proceed as indicated.
4. A press can also be used as shown, making use of two steel blocks for shafts where a sufficient amount of surface of the inner race can be used. In some cases the split ring can be used.
5. In the case of some of the larger bearings it may be necessary to heat the inner race. When this is done, extreme care must be used if the bearing is to be used again. As a matter of fact, when an excessive amount of heat is required, the bearing should be scrapped. Hot oil at 100 to 125 C is a good method of applying heat.
6. There are many types of bearing pullers designed to meet special conditions. Those shown above and below will cover most situations.

It is well to remember that cleanliness in handling ball bearings is most important, and care all along the line will pay dividends. It should also be kept in mind that it is just as bad to over-lubricate a ball bearing as it is to neglect the greasing operation. Properly installed and protected, these bearings should run for long periods without attention.

The material on which this article is based appeared originally in the Westco Reporter. The photographs are by courtesy of the Westinghouse Electric Corp.

Fig. 6. If the shaft has a shoulder below the bearing, rest the shoulder on the jaws of the vise

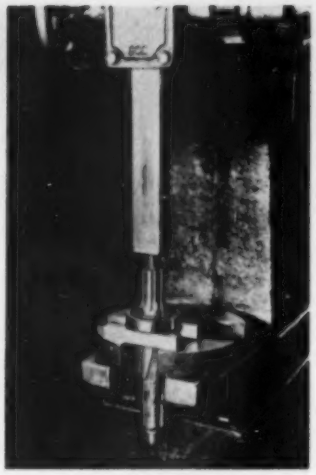
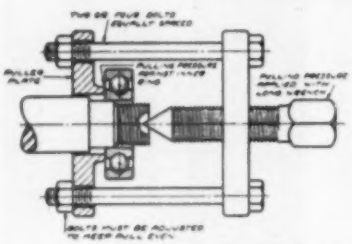
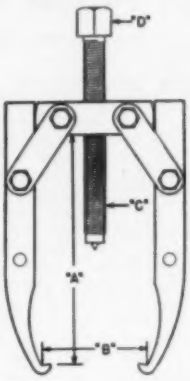


Fig. 7. A press can be used by making use of two steel blocks

Figs. 8 and 9. Two types of bearing pullers





Converting a Manual Spot Welder to a High-speed Resistance Welder

By HOWARD T. BAILEY
Supervisor, Electrical Maintenance
Brillion Iron Works, Brillion, Wis.

PRACTICALLY all Industrial plants employ the use of one or more spot welders in their sheet metal fabricating departments. There are many of these so-called "One shot welders" used on the assembly line whose productive speed could be greatly increased by the addition of a few parts by the plant electrician.

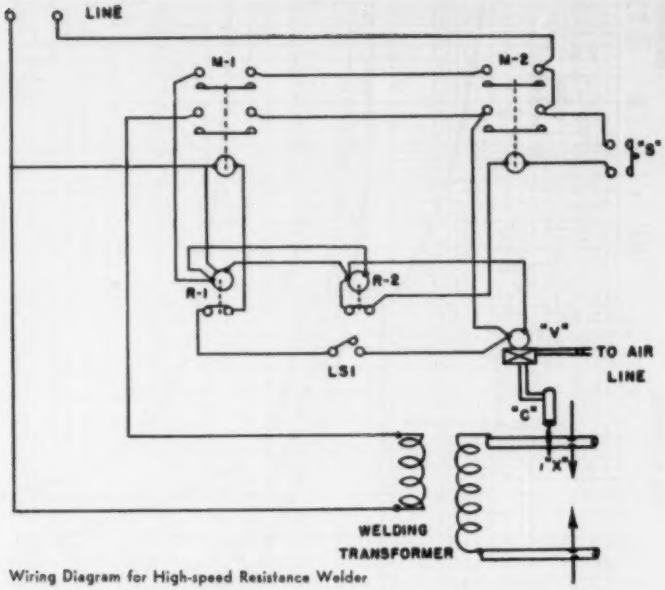
Where there is just one spot weld to be made on each piece the advisability of changing over to a high-speed welder may not be apparent at first thought but, once accomplished, the greater ease in operation makes the conversion very worthwhile.

On most all of these manually operated spot welders the setting of the machine is a very touchy and tiresome operation. The following operations usually have to be performed before a successful weld can be made. These setting up operations are as follows.

1. Adjust the contact pressure on the object being welded to a correct amount. (Insufficient pressure causes burning)
2. Set power contacts so that they trip at the exact moment.

Unless these two operations are properly coordinated it is impossible to obtain a good weld. Improper timing requires a higher amperage setting which in turn causes excessive sparking and usually burns instead of welding.

We have one of these manually



Wiring Diagram for High-speed Resistance Welder

operated spot welders that has always been a headache to the electricians. In the process of changing from one operation to another the down time was much too high and the scrap was no small matter either. New operators also had difficulty in becoming familiar with the machine. After conversion a new operator can do just as good a job as the experienced one, foot pressure having nothing to do with the quality of the weld.

The production department set up a new job to weld two ⅛ in. plates together. Several hours was spent by the electricians trying to get sufficient amperage out of the machine but with no results; finally the superintendent called in an engineer from a spot welder firm and after another seige of fixing this, and adjusting that, the welder was pronounced as too small for the job.

The Electrical Dept. made several changes as mentioned later in this article. The machine was tried out on the same job and the results were highly satisfactory.

With this conversion the following improvements can be attained.

1. Less fatigue
2. Uniform welds
3. Experienced operator unnecessary.
4. Instant adjustability for single spot or continuous spotting (stitching) in rapid succession.
5. Better welds at less amperage which will increase the life of the tips considerably.

Actual construction of this welder is very simple and even the apprentice electrician should have no difficulty in developing a successful spot welder that any maintenance or production department would be glad to have.

In assembling the unit there are no hard and fast rules to be adhered to, it being necessary only to wire the components as indicated.

In the list of material I have mentioned the manufacturer's name of certain parts. It is, of course, not necessary to strictly adhere to these particular brands but it is mentioned only as a guide in the selection of suitable relays.

Material list

M1-M2. Two pole magnetic switches.

S. Limit switch, normally open contacts. This is the foot pedal control and is no more than an ordinary limit switch with foot pressure plate attached.

R1-R2. A.G.A. Agastat time delay relay, adjustable from 0 to 15 seconds.

V. Solenoid air valve.

C. Small air cylinder.

LSI. Limit switch. Mount in position "X" as indicated on diagram. Adjust so that contacts close when sufficient pressure is obtained at welder tips.

They're experimenting with atomic energy on one of 'em

RELAYING in Industrial Plants

Selective relaying can be very effective in an industrial plant in reduction of disturbances on the electrical system. This article describes work done at the Bridesburg, Pa., plant of Rohm & Haas in adapting their relay system to the changed and expanded conditions brought on during the war. It shows how the Utility Co. and the customer cooperated in solving an important electrical problem

By S. S. PAIST

Power Engineer, Rohm & Haas Co.

Bridesburg, Pa.

OBTAINING SELECTIVE PROTECTION in the various electric circuits at the Rohm & Haas Co., Bridesburg, Pa., plant presented a problem because of the low time-current relay settings normally permitted by the utility on the incoming power supply. Close co-operation between the utility and the customer resulted in a satisfactory solution.

The Bridesburg plant is a medium-sized chemical manufacturing plant spread over approximately 60 acres and consisting of some 50 buildings. For years the electrical distribution system had been considered adequate even though little attention had been given to system stability under fault conditions. Those relays in operation were designed primarily to protect the utility supply rather than the plant system. For this reason, a major fault disturbance within the plant usually resulted in complete loss of the utility service. This was both costly and generally avoidable.

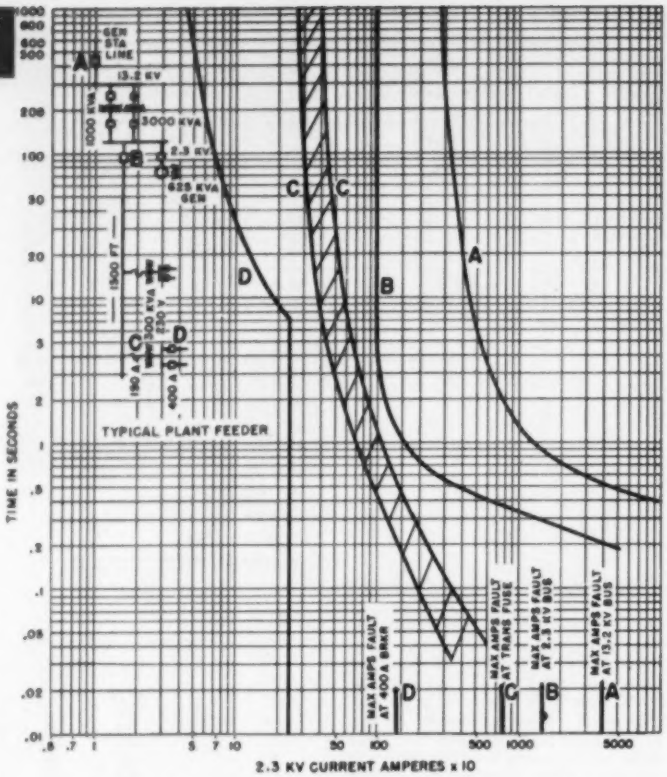


Fig. 2. The time-current curves of the overcurrent protective devices

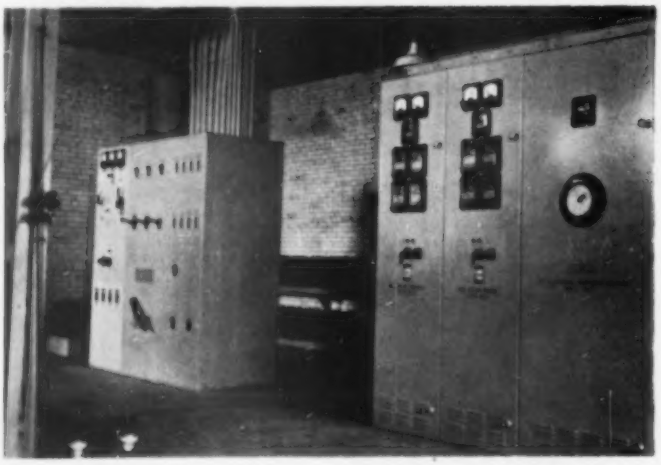


Fig. 1. The 230-v powerhouse distribution center and portion of the 13.2 kv switchgear plant substation

Under the impetus of wartime production demands, the plant electric load had grown to a point where system reliability was not keeping abreast of plant production requirements. A few minor relay changes were adopted during the war, but basic system design, production load requirements, and equipment shortages did not permit major alterations to the distribution system at that time. Therefore it was not until the electrical system was expanded later, because of increased plant demands, that the present relay installation was finally completed. While no* major relay alterations were made during the war, several 2.3 kv to 230 v plant power centers were installed to provide for increased plant demand. These transformer load centers were designed carefully to provide selectivity within the center as well as to fit into an overall plant scheme.

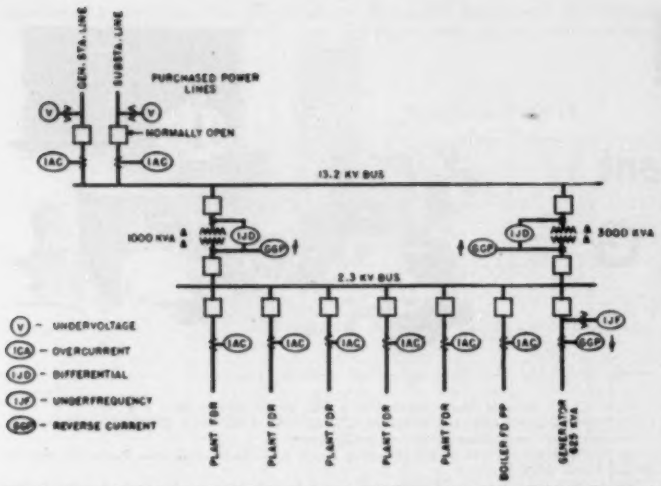


Fig. 3. General relaying and single line diagram of the equipment installed in the plant substation

The relay plan was based on two concepts which were recognized as important. First, it was obvious that improved reliability would become increasingly important as the system grew larger; second, however, the probability of faults would tend to rise in proportion to the size of the system. Also, the plant's past history included few system disturbances. The possibility that this fact might influence management views regarding capital investment for standby equipment and protective relaying was not overlooked. Design of the system was not permitted to run ahead of the plant engineer's ability to sell the reliability angle to management where plant history did not readily support the engineers' concepts. Emphasis was placed on adequately designed equipment. This proved important, for it not only diminished the probability of faults but also helped to gain concessions when selective relaying was being discussed with the utility.

Because the utility supply carried a major portion (approximately 77 per cent of the demand), the reliability and relaying of the utility system were studied carefully to determine to what extent the plant system should be relayed and to ascertain what problems would arise in coordinating plant relays with those on the utility system.

Some of the major problems which arose could be solved only by joint action between the utility and the customer. This required a full exchange of information on equipment specifications, proposed relay schemes, future planning, and general maintenance schedules. The utility apparently recognized that, as customers took larger blocks of purchased power, selective relaying within the customer's premises became more important. On the Rohm & Haas Co.'s part, it was recognized that the utility faced problems in protecting its system: troubles on a customer's equipment must not be allowed to create disturbances which would affect other customers fed from the same line. The selective relaying plan for the Bridesburg plant was based on the same principles—faults must not remain on the system long enough to damage equipment unduly or to cause wide disturbances. In this way, equipment not directly involved would continue to function. By adequate maintenance programs, by careful design in consultation with the utility and by the use of adequately designed equipment, much was done to influence the utility to permit time-current settings on our substation relays higher than it normally allowed. This allowed the company to achieve a better, more reliable electrical system.

Figure 3 indicates the general relaying and the single line diagram of the equipment installed in the plant substation.

An important part of the relaying scheme offered an obvious but rather involved problem: having the overload relays on the incoming 13.2 kv utility line set with sufficiently high time-current and instantaneous characteristics to allow enough leeway for selective operation of the 2.3 kv bus distribution circuit-breaker overcurrent relays. The utility company, primarily concerned with its own relay selectivity and system reliability, was reluctant at first to increase its standard time settings on the incoming lines. Fortunately, the normal-service 13.2 kv purchased-power line originated at a generating station. Since the line relays at the generating station were, so to speak, next to the relays on the line entering the Rohm & Haas substation, selective tripping could be achieved by merely holding plant relays under the time of those at the generating station. An emergency 13.2 kv purchased-power line originated at a utility company substation and interposed the substation relays between the generating station and the Rohm & Haas substation.

The utility considered this situa-

(Continued on page 88)

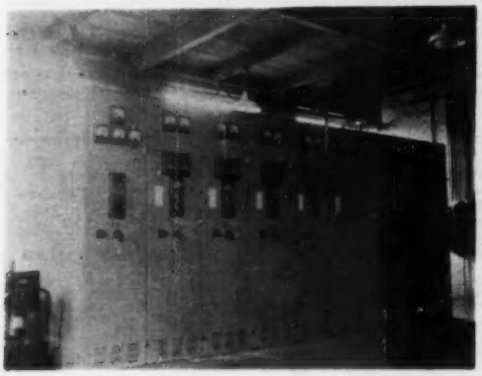


Fig. 4. A view of the 2.3 kv switchgear, Plant substation

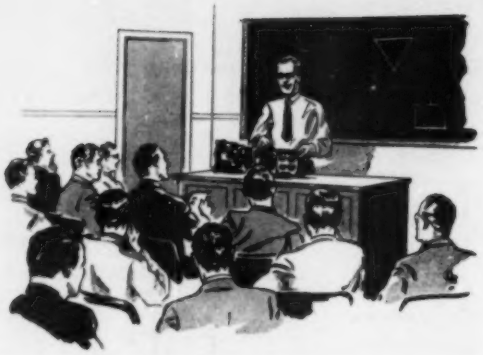
Fig. 5. Typical 2.3 kv to 230 v plant load center. Note compactness of the 2.3 kv feeder, fuses and 230-v breaker cabinet

THE PRACTICAL ENGINEER AND ELECTRICIAN

Basic Power Plant FIGURING

A Review for Old-Timers

A Must for Young-Timers



By WILLIAM H. ENGELMAN
Mechanical Engineer
Department of Water & Light
City of Cleveland, Ohio

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How to Use the Ellenwood-Mackey Charts for Steam in Turbine, Piping, Pressure Reducing and Other Steam Calculations

FOR DETERMINING all characteristics of steam under any conditions, with very little trouble, a set of charts entitled, Thermodynamic Charts, also Special Tables for Turbine Calculations, has been developed by Frank O. Ellenwood and Charles O. Mackey. Taking all the data from the steam tables and other sources, a large chart was worked out similar to a Mollier Chart, but with enthalpy plotted against volume instead of against entropy. For convenience in using, this enthalpy volume chart is cut up into 8½ by 11-in. sections and bound in book form. It is published by John Wiley & Sons, 440 Fourth Ave., New York City, and sells for $3.75. As you go along in steam engineering, you will find it to be a very convenient, accurate time saver in many of the steam problems you will encounter, along with the Mollier Chart and steam tables.

The Thermodynamic Charts enable you to find almost at a glance all the steam data usually required. The general range of each individual chart is given in the front of the book under the heading Index Chart for Steam. A typical example of one of the charts covering many of the steam conditions commonly encountered in industrial work, is given on the opposite page. The text explains the lettered points on the chart, shows how to use it and works out several specific examples.

Items usually needed for steam, whether wet, dry saturated, or superheated are as follows:

a. Steam pressure psia. (pounds per square inch absolute).
b. Steam temperature, t, (for wet or dry saturated steam), in deg F.
c. Total steam temperature TT, (for superheated steam), in deg F.
d. Degrees superheat, (TT—t), in deg F or total temperature minus temperature of saturated steam.
e. Volume in cubic feet per pound.
f. Entropy for any condition of the steam.
g. Enthalpy for any condition of the steam, Btu per pound.

How to Locate Items a to g incl., on the Chart, Plate 3 B.

The steam pressure lines are indicated, CONSTANT ABSOLUTE PRESSURE, psi. starting at the lower left and going almost vertically up.

The temperature for wet or dry saturated steam is shown by the extra heavy line marked SATURATED VAPOR.

The total temperature for superheated steam is indicated by the curved dotted lines running from left to right, CONSTANT TEMPERATURE, deg. F. The degrees superheat is the difference between the total temperature and that of the dry saturated steam at the same pressure.

The volume in cubic feet per pound for steam under any condition is given by the vertical lines running from top to bottom of the sheet and marked VOLUME, CUBIC FEET PER LB.

The region for wet steam, also known as quality of steam is located below the saturated vapor line and indicated as CONSTANT MOISTURE, per cent, the quality in per cent is 100 per cent minus per cent moisture.

The entropy lines starting at the lower right and running to the upper left are marked as CONSTANT ENTROPY and give this for any condition of the steam, whether wet, dry saturated or superheated.

The ENTHALPY, Btu per lb is so marked to the left and right of the sheet and is given by the horizontal lines, each line representing a Btu.

***Examples:*—How to Find Values on Ellenwood-Mackey Plate 3 B**

Item No.	PSIA	Total Temp. TT	Temp. Dry-Sat. Steam	Degree Super-Heat	Entropy	Enthalpy Btu Per Lb.	Volume Cu. Ft. Per Lb.	Plate No.
C	400	680	445	235	1.630	1352.0	1.620	3 B
D	400	445	445	None	1.485	1204.5	1.160	3 B
E	400	445	445	2.2% M	1.465	1187	1.130	3 B
H	200	530	382	148	1.640	1284.5	2.820	3 B
I	200	382	382	None	1.545	1198	2.280	3 B
J	200	382	382	2% M	1.525	1181	2.240	3 B

EXAMPLES: Steam at 400 psia and 680 F TT expands to 90 psia at constant entropy (See C-C_1). Find all items for initial and final condition of the steam. (Plate 3 B).

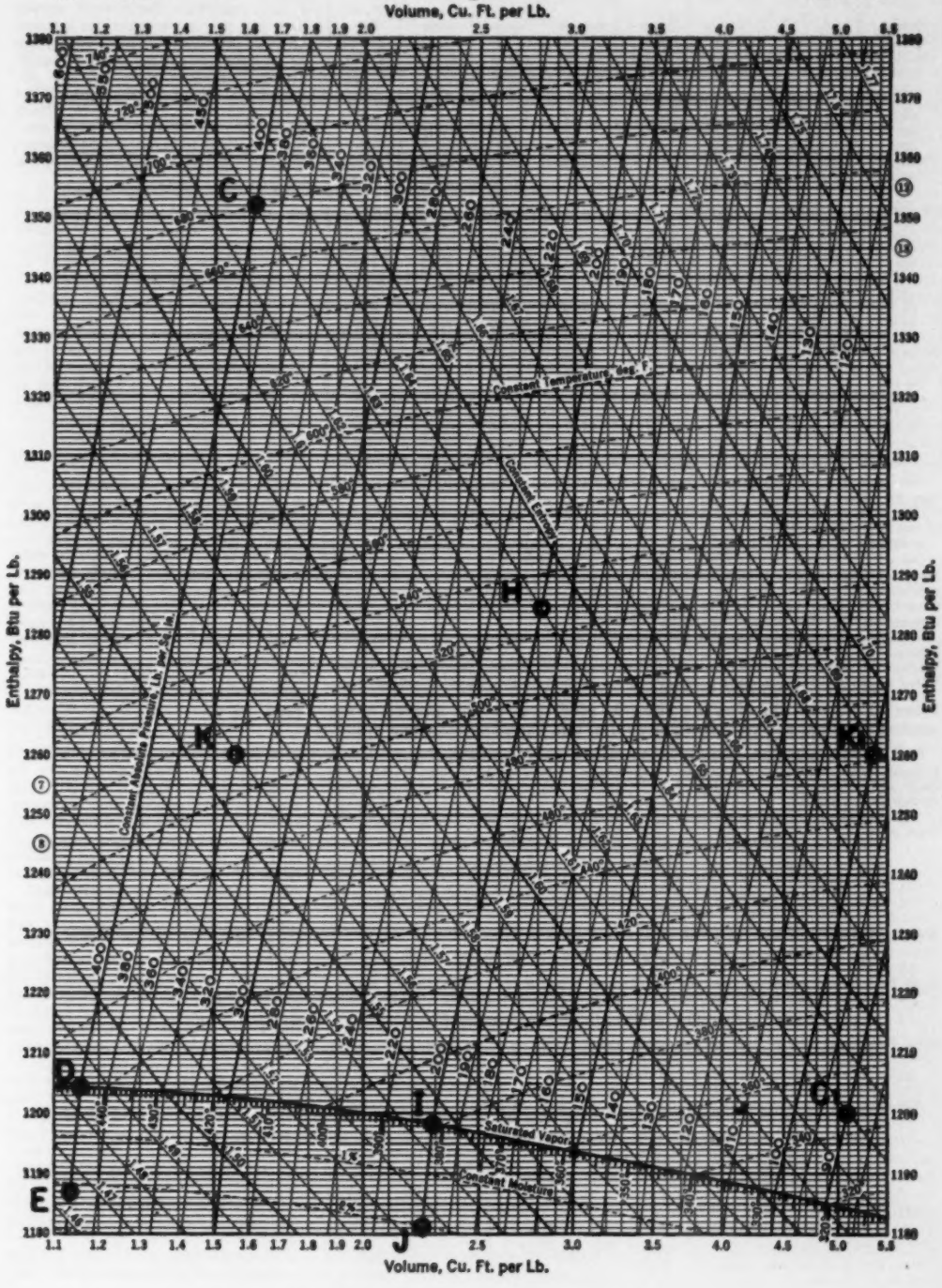
Steam at 340 psia and 512 F TT is passing through a reducing valve at 100 psia. See K-K_1. Find all items for initial and final condition of the steam. (Plate 3 B).

Item No.	PSIA	Total Temp. TT	Temp. Sat. Vapor	Degree Super-Heat	Entropy	Enthalpy Btu Per Lb	Volume Cu Ft Per Lb	Volume Ratio
C	400	680	445	235	1.630	1352	1.620	1.00
C_1	90	347	320	27	1.630	1200	5.100	3.15
K	340	512	429	83	1.560	1260	1.57	1.00
K_1	100	462	328	134	1.688	1260	5.35	3.41

(Continued on page 88)

Reproduced by permission from Thermodynamic Charts, 2nd Edition, by F. O. Ellenwood & C. O. Mackey, published by John Wiley & Sons, Inc., 1944. This is plate 3B from the book, showing steam conditions found in many industrial plants

(10) **STEAM** ⑨ **PLATE 3B**



BASIC POWER PLANT FIGURING

(Continued from page 86)

Volume per Pound of Steam under Various Conditions of Pressure and Temperature: Per Cent Moisture, Dry Saturated and Superheated.

Press. psia-in. Hg.	Steam Condition	Steam Temp. deg F	Super-heat, deg F	Volume Cu Ft per Lb	Relative Volume to Sat. Steam	Volume Ratio Vapor: Liquid	Plate No. From Charts
A	B	C	D	E	F	G	H
400	18.5% M.	444.6	None	0.95	0.8190	49.22	2 C
400	Dry Sat.	444.6	None	1.16	1.0000	60.10	2 C
400	Superheat	560	115.4	1.40	1.2069	72.54	3 B
400	Superheat	855	410.4	1.90	1.6379	98.45	3 A
400	Superheat	1100	655.4	2.28	1.9655	118.13	3 A
200	21.5% M.	381.8	None	1.80	0.7895	97.88	3 C
200	Dry Sat.	381.8	None	2.28	1.0000	124.00	3 B
200	Superheat	466	84.2	2.60	1.1404	141.38	3 B
200	Superheat	710	328.2	3.40	1.4912	184.88	3 B
200	Superheat	1000	618.2	4.30	1.8860	233.82	3 A
14.7	20% M.	212	None	21.4	0.7985	1280.0	4 C
14.7	Dry Sat.	212	None	26.8	1.0000	1602.9	4 B
14.7	Superheat	360	148	33.0	1.2313	1973.7	5 B
14.7	Superheat	630	418	44.0	1.6418	2631.6	5 A
14.7	Superheat	900	688	55.0	2.0522	3289.5	5 A
1 in Hg	20% M.	79	None	520	0.8000	33,338	6 C
1 in Hg	Dry Sat.	79	None	650	1.0000	40,423	6 B
1 in Hg	Superheat	160	81	750	1.1538	46,642	7 B
1 in Hg	Superheat	360	281	994	1.5292	61,816	7 A
1 in Hg	Superheat	620	541	1300	2.0000	80,846	7 A

Items A and B are usually known from which Items C, D, E and G can then be found from the plates given under Item H.

From these tabulations it can readily be seen that the volume of cubic feet per pound of steam is affected by:

a. Change in pressure; b. Change in Temperature; c. Moisture content.

Dry saturated steam at a certain pressure has a definite volume in cubic feet per pound; that is given as unity or 1.0000 under Item F.

Wet steam has less volume than dry saturated steam of the same pressure, since all the water has not been evaporated; but superheated steam has a greater volume due to higher temperature with the pressure remaining constant.

Pipe sizes are greatly affected by the volume of steam delivered in a specified time. Where steam is reduced through a pressure reducing valve, the conveying pipe must be substantially increased in size to carry the volume at the lower pressure. This is illustrated by the small supply pipes to steam engines or turbines and the large exhaust pipes.

Practical Problem showing the effect on pipe sizes with a change in the volume of steam due to reduced pressure. Use Ellenwood-Mackey Plates.

Flow of 15,000 lb of steam per hour at 140 psia and 2 per cent moisture passes through a pressure-reducing valve to 14.7 psia. Assuming a velocity of 6,000 fpm in the initial steam and 10,000 fpm (due to large pipe) in the final steam, what size pipes are required to deliver this steam?

From Plate 3C: Volume of initial steam is 3.13 cu ft per lb.
15,000 ÷ 60 is 250 lb of steam per min.
Volume per minute is 250 × 3.13 = 782.5 cu ft.

$$\text{Pipe area is } \frac{\text{cubic feet}}{\text{velocity}} = \frac{782.5}{6,000} = 0.1304 \text{ sq ft.}$$

From Pipe Data*: Use 5 in. Sched. 40 pipe; area is 0.139 sq ft. . . O.K.
Steam velocity reasonable; friction loss is 1.5 lb per 100 ft.

From Plate 5B: Volume of final steam is 29.0 cu ft per lb.
Volume per min. is 250 × 29 = 7,250 cu ft.
Pipe area is 7,250 ÷ 10,000 = 0.725 sq ft.

From Pipe Data: Use 12 in. Sched. 40 pipe; area is 0.7773 sq ft. . . O.K.
Steam velocity reasonable (1,000 ft per inch of pipe diameter); friction loss is only 0.12 lb per 100 ft.

Changing the velocity of the final steam to 12,000 fpm, we have:
Pipe area is 7,250 ÷ 12,000 = 0.6042 sq ft.
Use 10-in. Sched. 40 pipe; area is 0.5476 sq ft. . . O.K.
Actual Vel. in 10-in. pipe = 7,250 ÷ 0.5476 = 13,240 fpm causing a drop of 0.90 lb in 100 ft.
Friction loss is 0.90 lb per 100 ft of pipe.

NOTE: Volumetric Ratio of FINAL to INITIAL steam is 9.265 : 1.0, which explains the enormous increase in pipe sizes.

* Pipe Data means Tables A and B, Physical Characteristics and Data on Schedules 40 and 80 Pipe; POWER GENERATION, August and September, 1949.

RELAYING

(Continued from page 85)

tion carefully and decided to increase the time-current and instantaneous characteristics of plant substation relays on the normal supply line, but not to increase the settings on the emergency line originating at its substation. Full use was made of the increased time settings allowed on the normal line with the knowledge that, during short periods when the emergency line would supply the plant load, we could tolerate questionable relay selectivity under certain fault conditions.

The high-side fuses and low-side circuit-breakers of the company's 2.3 kv to 230-v and 120-v power centers fitted into the over-all selectivity picture as shown (Fig. 2) by the time-current curves of the overcurrent protective devices. Letters identifying the curves refer to the various protective devices shown and designated on the sketch of the typical plant feeder line. Current has been plotted against a 2.3 kv base as a matter of convenience. The interrupting ratings of the protective devices indicated are, of course, adequate for maximum fault current interruption.

From observations made as the design was formulated, it was found that to derive maximum benefits from selective relaying, it was important to co-operate actively with the local utility on all phases of the system design. Rohm & Haas Co. engineers firmly believe that careful relaying will pay dividends by preventing widespread system disturbances, and that industrial plants should not neglect this phase of their electrical system design.

FUEL OILS

(Continued from page 81)

3. The sediment and water present may be small, but again it can be considerable. Regardless of the amount, both water and sediment, especially water, will help to decrease the Btu value of a fuel oil.

4. The percentage of ash is usually small, but as it is non-combustible, there will be a loss of heat.

5. The sulphur content will vary from 0.25 per cent to 3 and 4 per cent. When a pound of sulphur is burned, only about 4000 Btu are liberated, as compared to 14,600 for carbon, and 62,000 for hydrogen. So, if there is a large amount of sulphur, there will be a decrease in per cent of carbon or hydrogen present, with a resulting lowering of the heat.

6. The amount of oxygen in a fuel oil is generally quite small. When it is present, it will unite with the hydrogen of the fuel to form water vapor, even before the secondary air, or oxygen supplied for combustion can reach the hydrogen. This results in a decrease in available hydrogen, decreasing the heating value.

These factors can usually be dismissed for all practical purposes, but

it will serve to illustrate why the heating values of fuel oils will vary. Of the seven factors mentioned, only No. 3 should cause any degree variation. Sometimes with residual oils like No. 5 and 6, the sediment and water content may be fairly high. It is possible to have from 5 to 15 per cent present, which would decrease the Btu value considerably.

Questions and Answers

Answer No. 461

WHY DO THRUST BEARINGS WEAR OUT?

IN THE APRIL ISSUE, J.T. showed the diagram of his single-width, single-inlet fan equipped with vortex control and inlet box, driven by two motors, coupled one on each end with flexible couplings. One is the low-speed, 60-hp, 865-rpm motor; the other the 125-hp, 1165-rpm high-speed motor.

On this fan, thrust bearings have been wearing out rapidly; they have used eight since February 1947. They have changed to lighter grease, re-aligned shaft and couplings. The fan is installed outdoors on the roof.

They are using SKF No. 22222 spherical, self-aligning roller bearings. Shaft is 4-13/16 in. in diameter.

The boiler is rated at 150,000 lb per hr and has been operating at about 110,000 lb per hr, with the fan running at the high speed and the louvers about 1/3 open.

Do they get too much thrust? Should they house and heat the bearing in winter? Or install heavier bearings? The bearings do not give any warning by overheating.

Several good comments on this appeared in the June issue and here are some more.

Thrust Bearing May Be on Wrong Side, Says Wendover

IF THE BOILER is used partly for a heating load, it seems that the bearing failures may have occurred during cold weather due to the more severe service demanded of them during these periods.

Most cage or spacer failures can be traced to faulty lubrication, however, other factors such as high load and speed can combine to cause rapid lubricant breakdown.

The thing most obvious from the sketch shown with the question is that the thrust bearing is located on the wrong side of the fan.

In a single inlet fan with an inlet box, the center of gravity of the wheel is much closer to the bearing on the fan side and this means that the greatest radial load occurs on this bearing. If this bearing is also made to carry all thrust loads, it is evident that the bearing will be very heavily loaded, while the other bearing will be very lightly loaded.

To lighten the load on the present thrust bearing, simply remove the stabilizing ring from this pillow block and transfer it to the other bearing, making that the thrust bearing. Some axial re-alignment of fan and motor shafts may also be necessary when this is done.

By decreasing the load on the present thrust bearing, lubricant life will be lengthened and less cage wear will occur.

Other possible changes in present bearing arrangement are:

1. Change to pillow blocks having triple seal, to minimize chance of moisture entering bearing housing. Many types of grease break down very quickly in the presence of water.

2. Change to bearings with better type of cages, such as machined bronze land riding type. For speeds and loads as high as these and with grease lubrication, this type of cage is usually used.

3. Change to oil lubrication (after consulting with bearing manufacturer). If fan is started up when grease is at very low temperatures, channeling can occur and result in a lack of lubricant available to the cage and rollers.

Nelsonville, N. Y. W. E. WENDOVER

Brusca Doubts It's the Thrust Load; May Be Several Other Things

A SINGLE-INLET, single-width fan develops a thrust load of small magnitude and it is doubtful if this thrust load would impose any appreciable load on the bearing. Usually the selection of the bearing size for an industrial fan is dictated by the diameter of the shaft, for the latter must be large enough to reduce deflection to a minimum. The bearings, therefore, should have adequate capacity for the loads involved. The repeated bearing failures can be due to the following possible causes:

1. Lubrication
2. Opposed bearing mounting
3. Misalignment
4. Entrance of foreign matter into the bearing housing

Lubrication: If the temperature differential between summer and winter months is great, it would be wise to use a grease of lighter consistency in cold weather. The bearing housing should never be over one-half full of grease as excessive lubrication will result in elevated temperatures and possible breakdown of the lubricant.

Opposed bearing mounting: A check should be made to be sure that one bearing only is held axially in the housing. The other bearing must be mounted with adequate clearances between the outer race and the housing shoulders to permit axial expansion and contraction of the shaft. If the floating bearing is mounted with the outer race against the housing shoulder both bearings are apt to be preloaded axially when the shaft expands or contracts.

Misalignment: It is important to have both motor shafts in perfect alignment with the fan shaft. Flexible couplings will compensate for a slight angular misalignment but will not take care of a condition where the shafts are parallel but slightly off center.

Entrance of foreign matter into the bearing housing: If the seals in the bearing housing are not effective enough to provide adequate protection for the bearings, a shroud should be applied over the bearing housing. The shroud should be designed to cover the entire housing with openings at each end to permit the shaft to extend through with a minimum amount of clearance.

Note: It might be well to use bearings with slightly greater internal clearance than standard, to compensate for any temperature differential between the inner and outer races.

Philadelphia, Penna. J. L. BRUSCA

Check With Bearing Manufacturers, Advises Butcher

BEARINGS WEAR OUT because they are overloaded, over-lubricated or under-lubricated, are out of alignment, get dirt in them, or are not properly mounted. A fan bearing needs to be well sealed if it is exposed to the flow of air along the shaft, or it may quickly become loaded with dirt or the lubricant may be carried out by the air stream.

Your fan will have a combination radial and thrust load on the thrust bearing and, because of its construction, one or both of these loads may be greater than the designer calculated.

Tapered roller bearings are built in much greater capacity than your fan could possibly require, therefore I would suggest that you check each possible cause of failure and call in an engineer from the manufacturers of tapered roller bearings for advice as to the particular type and size of bearing to install. Certainly eight bearings in three years are too many. In fact, the original bearings should still be operating if they were of suitable capacity, were properly installed and had received standard care.

Ball and roller bearings are designed for a definite number of hours of service under given load conditions. The lighter the load for a given bearing, the longer its life will be; in other words, heavy loads must have heavy-duty bearings for long life.

Cincinnati, Ohio IRA A. BUTCHER

Riverton Laid Out for Ease of Operation

By DWIGHT COLLMUS
Power Department
The Potomac Edison Co.

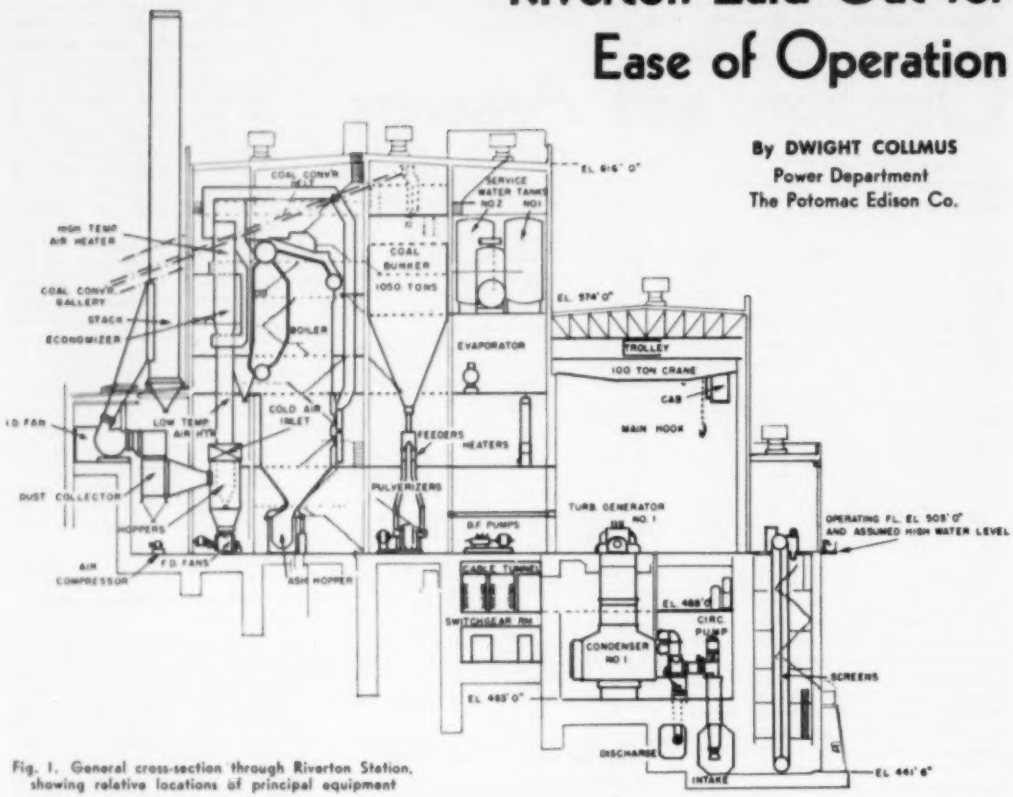


Fig. 1. General cross-section through Riverton Station, showing relative locations of principal equipment

NOW IN full operation, The Potomac Edison Co's. new 40,000-kw Riverton Station is located on the north bank of the Shenandoah River, about three miles north of Front Royal, Virginia.

For the initial 40,000-kw GE turbine generator, steam is supplied at 850 psig, 900 F by one Riley 350,000-lb-per-hr pulverized-coal-fired steam generating unit. The unit generates electrical energy at 13,800 v; this is stepped up to 33,000 and 132,000 v for transmission to various system load centers. Sanderson & Porter were design and construction engineers for this station.

In line with the modern trend, centralization and accessibility were given prime consideration in laying out the station. As a result, a large portion of the vital equipment is located on one floor, as shown in Figs. 1 and 5. Equipment situated on the main operating floor, at El. 505, includes: the central electrical and mechanical control room; the turbine generator; the boiler feed pumps; the traveling water screen drives; the pulverizers; the ash

Fig. 2. View in central mechanical and electrical control room

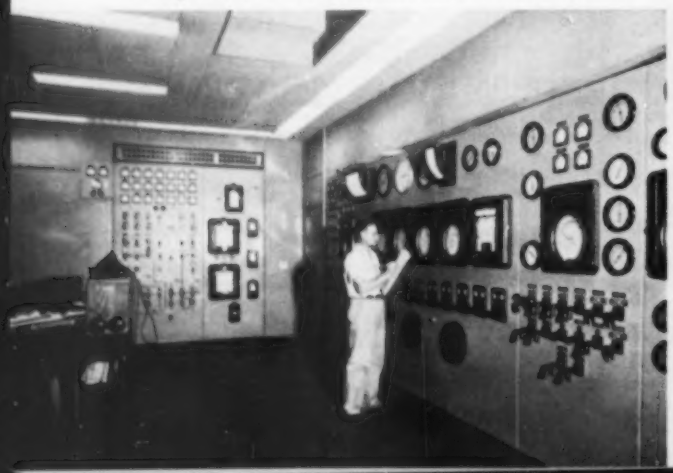


Fig. 3. General view of Riverton Station

pumps and ash sluicing system; the forced draft fans; the station air compressor; the control air compressors; the relay and 13,800-v switchgear room; the spare exciter; and the emergency gasoline-motor-driven generator.

Such extensive centralization unquestionably facilitates both operation and maintenance. Furthermore, with regard to maintenance of other station equipment, it should be noted that, as a result of the contour of the land, the railroad siding enters the station at an elevation 25 ft above the operating floor. At this higher level are located the coal feeders, the induced draft fans, and easily accessible are the substation transformers, the coal crusher, and other outdoor equipment. Thus, this equipment can be loaded on rail cars, moved inside the station, and lowered to the shop floor by either the 100-ton main hook or the 15-ton auxiliary hook of the turbine hall traveling crane. This crane may also lift condenser-pit equipment through the turbine hall hatchway to the maintenance shop work space.

With equipment arranged in such a manner, the operation of the station revolves around a nucleus of three men: the shift foreman and his assistants, Operator A and Operator B. Operator A is responsible for tending the boiler and its various related equipment. Operator B is charged with tending the turbine generator, its related equipment, and with performing switching operations both indoors and out. The shift foreman is directly responsible for the operation of all equipment in the plant and substation. His usual working post is the electrical and mechanical control room, from which he can observe the performance of all important operating equipment by means of meters, gages, thermocouples, and other devices. Here, too, he can control the operation of these major units of equipment by the numerous switches and regulating devices at his disposal. Furthermore, the shift foreman maintains instant contact with his operators and the station superintendent's office by means of a public address system.

Coal handling, testing, and maintenance work are taken care of by additional men on a five-day, day-shift basis.

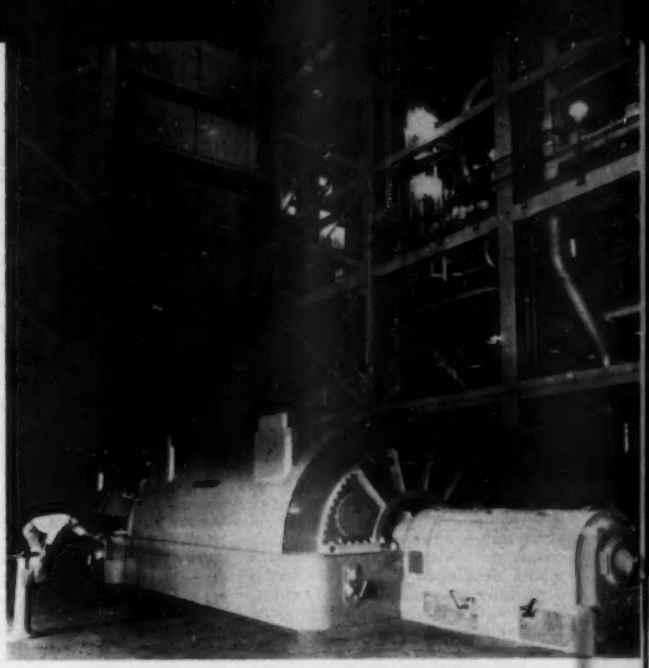


Fig. 4. View on main operating floor, Riverton Station, looking across the 40,000-kw, 850-psi, 900-F, 3600-rpm turbine generator towards the steam generating unit and its auxiliaries

Considerable operating experience—frequently under adverse conditions, particularly with regard to the feeding of coal—beginning on August 25, 1949, when the unit was first placed on the line, has proved this minimum assignment of operating posts to be entirely satisfactory.

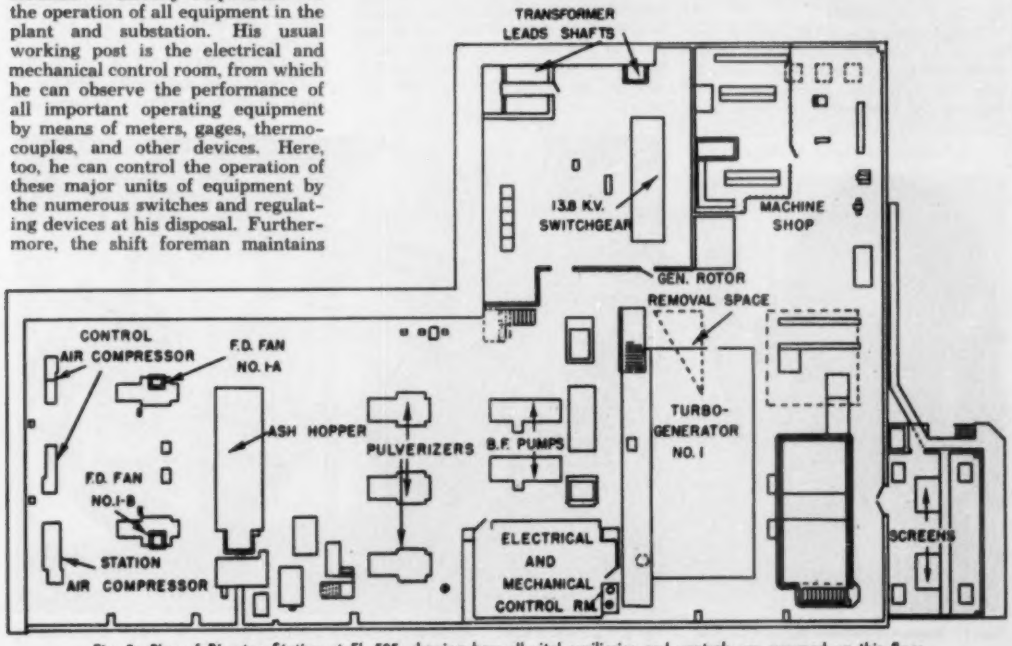


Fig. 5. Plan of Riverton Station at El. 505, showing how all vital auxiliaries and controls are grouped on this floor

Steam Plant Practice in Britain

This unusual survey compares British steam plant and fuel burning practice with ours, as it is right now in 1950 . . . British engineers, handicapped by slow equipment replacement, must burn low-grade, expensive fuels in equipment built previously for high-grade cheap fuels . . . Types of fuels now available . . . Fire-tube types of boilers predominate for small and medium-size steam plants . . . Fired by hand and by various types of stokers, as described . . . Larger industries and utilities have water-tube boilers and firing equipment like ours . . . How sandwich and "assisted" firing are used

By CHARLES H. MARKS
Project Engineer, Union Asbestos & Rubber Co., Chicago
(formerly: Powell Duffryn Technical Services, Ltd., London, England)

REPLACEMENT of capital equipment in Great Britain is slow, and a large section of British industry to-day employs steam plants developed in times when a plentiful supply of high-grade cheap fuel was available. The high rates of combustion then possible allowed relatively small grate areas and the low cost of fuel did not warrant extensive heat exchange surfaces. Since the war, however, British industry has had to face a considerable increase in the cost of fuel together with a steadily deteriorating quality. In addition there has been an insistent demand for the utilization of low-grade fuels, particularly in the mining areas. The problem of adapting existing plant and practice to these new conditions is facing the British fuel engineer on almost every level of utilization.

Fuels

Britain uses about 190,000,000 tons of coal for home consumption. Some 50,000,000 tons of solid fuel, including coke breeze, slurry etc. are burned in shell-type boilers, and some 30,000,000 tons in water-tube boilers including utility power stations.

The cost of oil to the British consumer is high and only 3,000,000 tons per year are burned representing 1.8 per cent of the total yearly heat consumption in Btu. There is no natural gas. The high cost of manufactured gas (termed "Town's Gas") allows its application only to small domestic space heating installations and for certain high-grade metallurgical and drying purposes.

Almost all of Britain's coal is bituminous or semi-bituminous coal covering the whole range from low to high volatile and from free burning to strongly coking. Although only 2.6 per cent of the output is obtained by completely mechanized mining, mechanization is steadily increasing. The bulk of the output is graded at the source, and 90 per cent of the industrial small coal is subjected to some form of cleaning, mostly by wet washing (86 per cent).

Mechanization and the standard of labor have caused deterioration of the quality of fuel. It is estimated that the average ash content now is some 50 per cent more than before the war and some 11 per cent of the salable output passes ⅛-in. screen. Furthermore coal is a valuable export commodity to Britain (16,000,000 tons per year at present) but only as far as her high grades are concerned, which in turn throws a heavier proportion of the lower grades on the home industry.

Small Industrial Consumer

For small outputs of steam up to 1500 lb per hr (50 blr hp) a vertical cross-tube boiler is commonly used, but the most popular boiler of the small industrial coal consumer generating from 1500 to 6000 lb per hr of steam is the vertical fire-tube boiler. As seen from Fig. 1, it is self-contained, with the furnace being an integral part of the boiler.

Efficiency of the vertical boiler is fairly high, but its disadvantages are

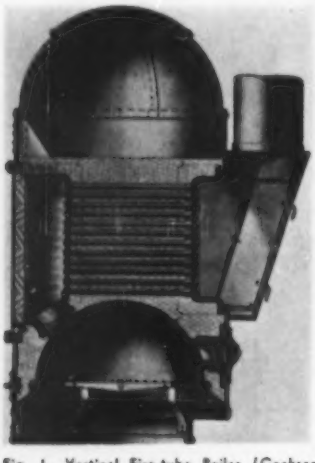


Fig. 1. Vertical Fire-tube Boiler (Cochran & Co., Annan, Ltd.)

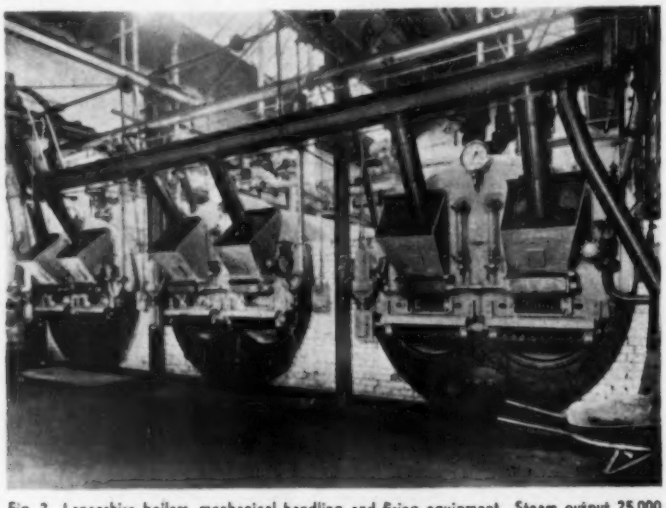


Fig. 2. Lancashire boilers, mechanical handling and firing equipment. Steam output 25,000 lb per hr ("Hodgkinson," Manchester, England)

need for a reliable source of soft water and restricted combustion space, necessitating a good grade of coal. Many boilers are hand-fired but several have been fitted with forced-draft furnaces to burn low-grade fuels. For mechanically-fired installations, the underfeed stoker is invariably used and in most cases is automatically controlled. The same types of underfeed stokers are used as in the United States. Up to 25 per cent fines are being burned with little difficulty but greater proportions have been used depending on the percentage of fines and coking properties.

Medium-size Consumer

For installations generating up to a total steam output of 50,000 lb per hr, the most popular boiler is the Lancashire boiler. It is made in sizes up to 10 ft in diameter and 32 ft long, with an evaporative range up to 12,000 lb per hr and pressures up to 220 psi. Its advantages are low first cost, long life up to 40 years, low maintenance cost, high steam storage capacity for fluctuating loads, and independence of an expensive water-treatment plant, even with relatively hard water.

Figure 2 shows a typical Lancashire boiler plant. The boiler is brick-set. Combustion takes place on the fire-grate inside the furnace tubes and combustion gases pass into a smoke chamber at the rear end, where they are returned in a brick-set pass underneath the boiler to the front. There they split and pass back along the sides and to the stack.

Gas velocities are necessarily low, resulting in low rates of heat transfer, once the gases have left the radiation zone. It has been estimated that 83 per cent of the total heat exchange takes place in the water-cooled furnace tubes of the Lancashire boiler. The ratio of heating surface to grate area is 20 to 30:1, which, with good firing, gives an exit gas temperature of some 850 F, and an efficiency of 65 per cent at rated capacity.

Use of Economizers

To-day almost every boiler plant of this size is fitted with an economizer to absorb a proportion of the heat in the flue gases leaving the boiler. By this means the waste gas temperature is reduced to about 400-450 F. Most popular type of economizer is still the Green straight-tube economizer consisting of vertical banks of 4-9/16-in. diameter cast-iron tubes with the gases passing over the outside. A scraper gear moves slowly up and down to prevent deposits. More recent types consist of steel-tubes with cast-iron fins and soot-blowers for cleaning.

A typical lay-out of a three boiler installation is shown in Fig. 3. Each unit is 8 ft 6 in. diameter by 30 ft long and rated at 8000 lb per hr. There is a 124-tube economizer, fitted with a by-pass for starting up and cleaning.

The Economic Boiler

Several improvements have been made to the shell-type boiler, of which the Scotch Marine boiler is the best known in the United States. A later development is the "Economic" boiler, which is becoming increasingly popular in Britain.

In this boiler, Fig. 4, the combustion gases, after reaching the smoke chamber, return through banks of small diameter tubes at a fairly high velocity to the front of the boiler. Depending on the design, the gases either discharge through the stack or else are returned through an additional pass of tubes to the rear before they discharge to stack. The high gas velocities, together with the larger heating surfaces presented by these tubes, give a more compact boiler and a higher efficiency than the Lancashire boiler. Ratios of heating surface to grate area vary

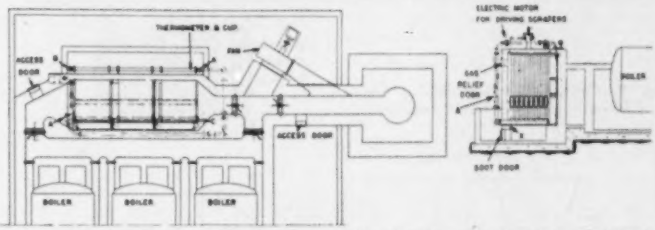


Fig. 3. Straight-tube economizer for three boilers (E. Green & Son Ltd., Wakefield, England)

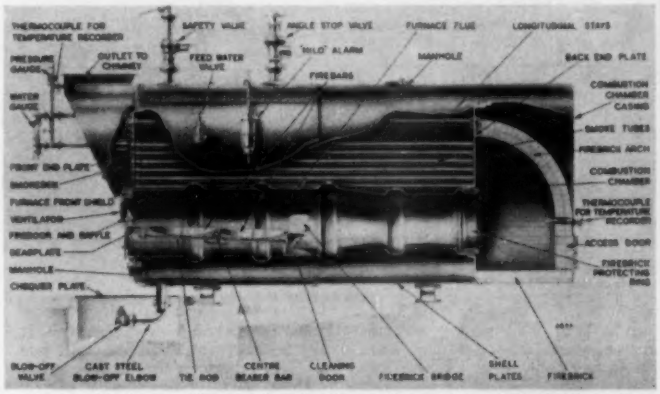


Fig. 4. Double-pass "Economic" boiler (Davey Paxman & Co., Ltd., Colchester)

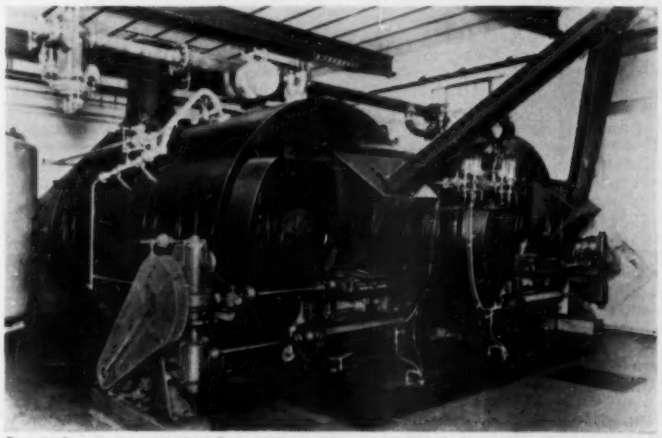


Fig. 5. Three-pass wet-back "Thermax" boilers mechanically fed and fired. Steam output: 15,000 lb per hr (Boilers: Ruston & Hornsby Ltd. Lincoln; Stokers: "Hodgkinson," Manchester, England)

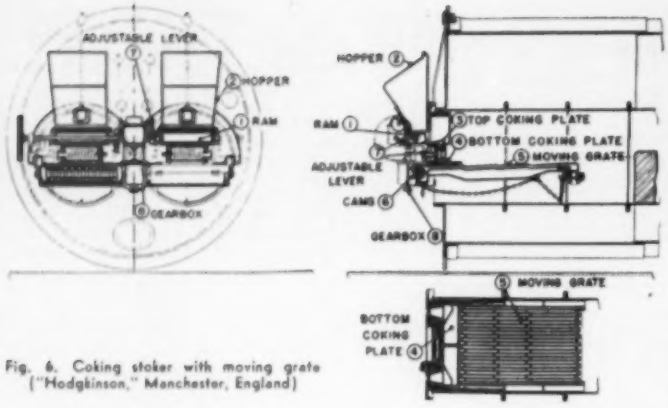


Fig. 6. Coking stoker with moving grate ("Hodgkinson," Manchester, England)

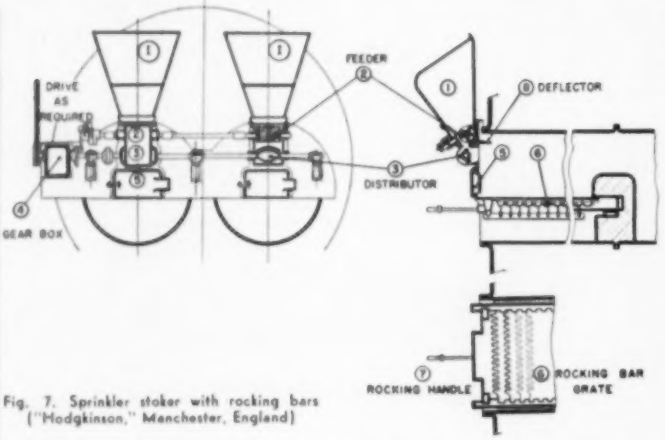


Fig. 7. Sprinkler stoker with rocking bars ("Hodgkinson," Manchester, England)

from 30:1 to 60:1 giving an efficiency of some 75 per cent compared with 65 per cent for the Lancashire boiler at full rating.

Thus, a Lancashire boiler rated at 10,000 lb per hr of steam would be 9 ft diameter by 30 ft long, burning 1230 lb per hr of coal at 12,500 Btu per lb; whereas an Economic boiler having the same steam output would be 9 ft diameter by only 15 ft 6 in. long and burning only 1070 lb of coal per hr.

Disadvantages of this type of boiler are its higher water treatment and maintenance costs. A reliable external water-treatment plant is necessary in most cases and the firetubes have to be cleaned regularly.

Steam output is determined by available grate area for given draft conditions. In all British shell-type boilers, the grate area is curtailed by the permissible diameter of the furnace tubes and the length of the grate that can be properly controlled by hand. Consider, for instance, an 8 ft x 30 ft Lancashire boiler, without economizer. The grate area cannot exceed 41 sq ft and the combustion rate of a high-grade coal of 13,500 Btu per lb with sufficient draft may be taken at 25 lb per sq ft per hr. Heat release in the furnace tubes is, then, 350,000 Btu per sq ft per hr and the thermal efficiency 65 per cent. Under these conditions the boiler will produce 8100 lb per hr of steam.

The present quality of coal, however, makes it impossible to maintain such conditions. The burning of lower grades is usually accompanied by (a) a drop of combustion efficiency due to an increase of excess air, (b) a drop of thermal efficiency due to a reduction of flame temperature and therefore radiant heat transfer, and (c) a loss of fines through the grate. Since the grate area of such boilers cannot be enlarged, the designer, or operator, would have to allow for a considerable increase in combustion rate (Btu per sq ft per hr), if the same evaporation is to be maintained.

Assuming a 1½-in washed slack of 11,500 Btu per lb has to be used, a boiler efficiency of not more than 60 per cent may be expected. Consequently, for the output of 8100 lb per hr, a heat release of 380,000 Btu per sq ft per hr and a combustion rate of 32 lb per sq ft per hr would have to be specified. This almost invariably requires additional draft, and involves excessive carry-over and possibly clinkering with the lower fusion temperature ash often encountered with high-ash coals.

Under these circumstances, the only resource open to the British engineer for reducing the rate of combustion is the installation of additional boiler units, providing added grate area at the expense of excessive capital investment.

Types of Firing Equipment

Many installations are still hand-fired. The lack of graded coal required by most mechanical stokers has been a contributory factor retarding mechanization of British boiler houses. It is estimated that some 50 per cent of the shell boilers are still hand-fired. In colliery boiler plants or coke-oven boiler plants, slurry and breeze are hand-fired on specially designed forced-draft grates at firing rates of up to 50 lb per sq ft per hr. Installed boiler capacity is necessarily large.

Several well-designed mechanical stokers are available for shell-type boilers;

1. Coking Stoker, Fig. 6. This stoker consists of rams which move the fuel on to a front dead plate where it "cokes," giving off a large proportion of its volatiles. The grate consists of a number of 6-ft long bars which move forward in unison but return in groups of three or four. By this means they gradually move the fuel bed forward and keep it "open." The speed and thickness of bed is so adjusted that combustion is just completed at the end of the grate and that the ash discharge contains only a small percentage of combustible matter. This stoker requires a graded low-ash slightly caking bituminous fuel, and also skilled attention to maintain good efficiency.

2. Spreader (Sprinkler) Stoker, Fig. 7. There are several versions of this type of stoker employing rotating or flipping shovels to distribute the fuel on either a stationary grate or a "self-cleaning" grate which is similar in action to the grate of the coking stoker. This type of stoker can handle a greater variety of fuels of higher ash contents and greater proportions of fines than the coking stoker. Its drawbacks are high grit (dirt, fly ash cinder) emission and sooting up of the heat exchange surfaces of the Economic type boilers when attempting to obtain high firing rates over 30 lb per sq ft per hr.

3. Underfeed Stoker. This stoker has never become popular for shell-type boilers, due to its selectivity of fuels and relatively high maintenance costs.

4. Chain-grate Stoker, Fig. 8. The development of the chain-grate stoker for shell-type boilers is the latest, may be the final attempt, to

save this boiler in the face of increasing supplies of lower grade fuels. This stoker consists of machined links with air spaces of only 2-mm. It has forced draft air supply and three compartments which may be regulated from the front. Coke breeze, anthracite duff, colliery fines, and the like, have successfully been burned this way at rates of combustion of up to 40 lb per sq ft per hr, but due to the limited grate area a drop in steam output cannot be avoided. Nevertheless, this is the only mechanical stoker with which high firing rates may be maintained on low grade fuels without excessive grit emission or excessive maintenance costs.

The limitation of grate area is a serious problem on all meduim size boiler plants in Britain at the present time. If grate area could be adjusted to the fuel, as is possible with the externally-fired multitubular boiler, or the water-tube boiler, a great many difficulties would be solved.

Larger Industrial Consumers

For steam output upwards of 50,000 lb per hr the conventional water-tube boiler is found and is usually chain-grate stoker fired. Refractory and water-cooled furnaces are in use. Compartment-type stokers with balanced, or induced draft and high-pressure secondary air, are common. Most of these units are fitted with economizers, either as an integral part of the boiler or straight-tube economizers serving two or three water-tube boilers. Pulverized fuel installations are rare except a few in mining areas. Little comment need be made on this equipment as the American engineer is thoroughly familiar with the scope of the industrial water-tube boiler.

Several methods have been adopted for utilizing low grade fuels. "Sandwich" firing, i.e. burning a layer of high-volatile bituminous coal with a layer of high-ash high-moisture fuel below, has been successfully adopted.

In one plant a bituminous filter cake containing 12.6 per cent ash and 28.2 per cent moisture is allowed to bake on a platform in front of the boiler and is then hand-fed onto an extended chain-grate. Ignition takes place under a long front arch. Under test, firing rates average 24.2 lb per sq ft per hr and boiler efficiency 79.4 per cent.

Another development has been "Assisted Firing." By this method a small amount of oil (4 per cent) is injected through the ignition arch and burned just below to provide a high-temperature ignition zone. This arrangement enables high outputs and efficiencies to be maintained with low grade fuels and conventional furnace designs. It is particularly useful to existing plants which have to face a sudden drop in coal quality due to economical or other reasons.

Steam jets fitted at the front arch and blowing against the direction of travel of the grate have also been found successful. The high velocity jets draw some of the hot combustion gases from the furnace and blow them under the arch to maintain ignition temperature.

Utility Stations

About 23,000,000 tons of coal are burned in utility power station boiler plants. Boiler units vary from 175,000 lb per hr to a maximum of 550,000 lb per hr. The older stations, used mainly for peak loads, still use traveling grates or chain grates, but the newer base load plants employ pulverized fuel firing, for reasons well known to all boiler engineers. There is only one small spreader stoker unit in operation and this is still regarded as experimental.

One 525,000 lb per hr slag-tap unit is in existence with the following steam conditions: pressure 1275 psi and temperature 975 F. The largest unit is pulverized-fuel-fired with the following data: output 540,000 lb per hr, pressure 1350 psi and steam temperature 965 F. (Fig. 9.)

Research and Development

Apart from some research work carried out by the boiler manufacturers most development work is covered by two organizations, the Fuel Research Board of the Department of Scientific and Industrial Research, and the British Coal Utilization Research Association. The former is financed directly by the Government and the latter by the National Coal Board. In effect the Fuel Research Board concentrates more on fundamental work and the British Coal Utilization Research Association on industrial application, but there are exceptions.

A great deal of work has been done on the testing of shell-type boilers, their mechanical stokers, on

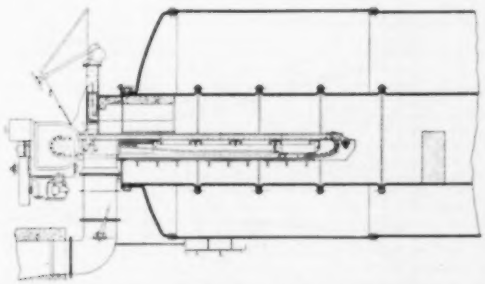


Fig. 8. Chain-grate stoker on Lancashire Boiler (Edwin Danks & Co. (Oldbury) Ltd., Oldbury)

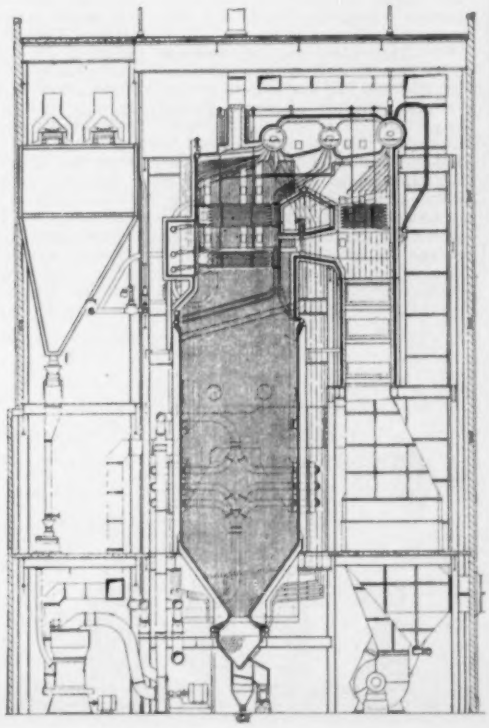


Fig. 9. Modern British water-tube boiler. Output: 540,000 lb per hr (International Combustion Ltd., London)

boiler availability and the utilization of low-grade fuels. An interesting development is the down-jet furnace in which air in introduced through jets arranged over the fire-bed instead of through the fire-bed as in conventional firing.

During the war the Government recognized the need of the small and medium-sized coal consumer for skilled technical advice and organized a small force of trained fuel engineers to fill this gap. There were 79 engineers, and 25 boiler operators for practical demonstration and teaching purposes. This organization has been retained and expanded to advise industry on their frequent fuel problems. Constant efforts are being made to spread the use of boiler house instruments for operation and testing. There is little doubt that the efficiency of the average industrial boiler house in Britain has been considerably increased as a result of the Government's effort.

A recent development in the field of fuel engineering has been the growth of a large private organization specializing on mining and utilization of coal. It was founded a few years ago by one of the largest South Wales mining companies out of the money to be received from the Government for the sale of the Company's mines. The organization acts as consultant in the exploration and utilization of fuel resources in all parts of the world and is equipped with extensive research laboratories and a highly trained technical staff.

The dissemination of information on fuel resources and research is undertaken by the Institute of Fuel. It has recently been granted official recognition to be of equivalent status with the other recognized techincal Institutions.

Combustion experience gained in Britain may be of some value to coal users in this country. After all, the efficient utilization of all types and grades of fuel is becoming of increasing importance as the price of fuel remains high.

New Pump-Turbine Stimulates Interest in Pumped Storage Development

ALTHOUGH not many pumped storage types of hydroelectric plants have been installed in the United States for various reasons, there has been much more interest in them in Europe and there are a number of important installations of them there. Also, a good deal of research work has been done by various European manufacturers on both pumps and turbines and combination pump-turbines for this work.

Now, however, the engineering and research staff of an American manufacturer has carried out a considerable amount of work during the past few years on the pump-turbine. And this promises to lead to some interesting developments. The manufacturer is Allis-Chalmers Manufacturing Co. and the developments were explained in detail at an interesting conference on Pumped Storage Hydro-electric Power held June 1 at Milwaukee, under the auspices of the company. At that conference several papers were presented by Allis-Chalmers' engineers giving much detail of the new unit the company has developed.

In a pumped storage type of plant, electric power is used during low load or off peak periods to operate pumps which pump water into a reservoir from which it can be discharged during peak load periods through hydraulic turbine generating units to supply valuable peak power. The electric power may be supplied by a transmission system and usually in connection with the installation a hydro-electric generating unit or units are installed so that the pumping plant can be operated even though disconnected from the large transmission system.

In most of the pumped storage plants built, at least in this country, the pump has been of more or less conventional design, although sometimes of large size and entirely separate from any hydro-electric generating units installed. However, since it has been known for a long time that pumps reverse on failure of their driving power and operate as turbines, the idea of designing a single unit to operate either as a pump or as a hydraulic turbine seems very logical.

The advantages of having a unit that can operate in one direction as a pump and in the other as a hydraulic turbine are or should be obvious. A single unit will decrease manufacturing, installation, and operating costs. There are, of course, a number of problems in the design of such a unit and it is these problems on which the Allis-Chalmers' Hydraulic Department have been working for some years.

A single unit must have proper characteristics as a pump as well as a hydraulic turbine, but fortunately these are not too far apart to begin with. The driving motor for the pump must reverse and operate as a generator with characteristics satisfactory for the system to which

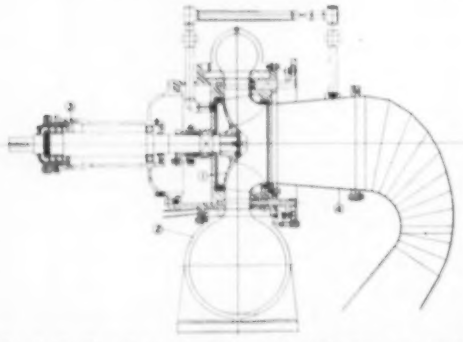


Fig. 1. Section of pump turbine model of the type now on test by Allis-Chalmers. 1—Runner, 2—Casing, 3—Shaft, 4—Draft tube

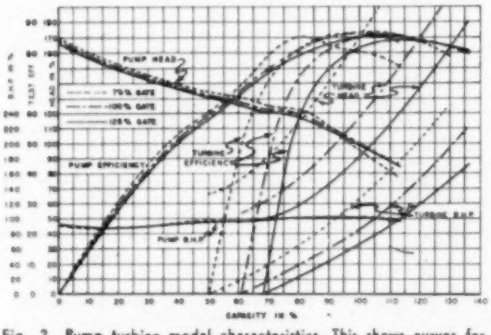


Fig. 2. Pump turbine model characteristics. This shows curves for the unit operating both as a pump and as a turbine. Note that pump head capacity per cent horsepower at best possible efficiency for 100 per cent gate was used to calculate percentages

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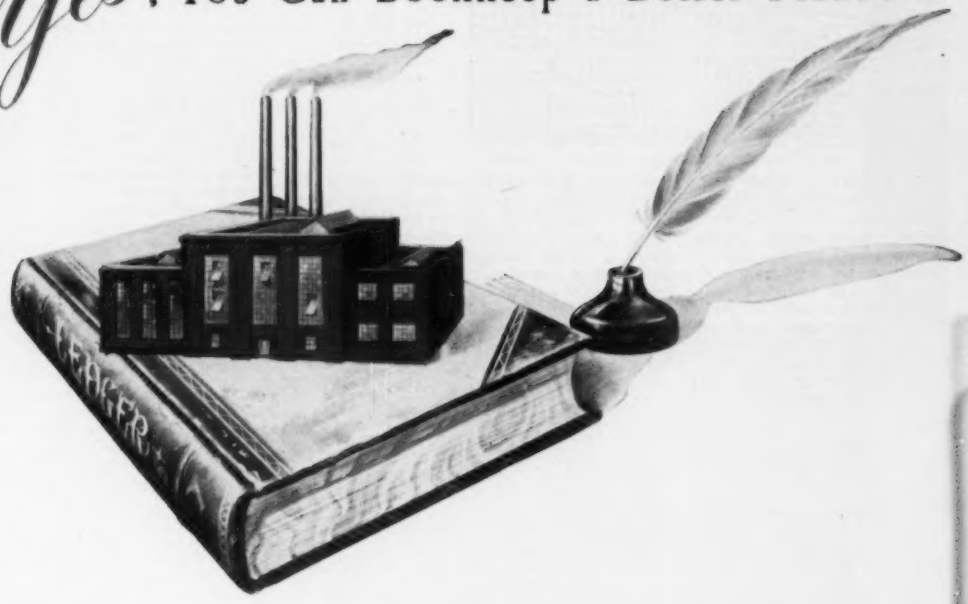

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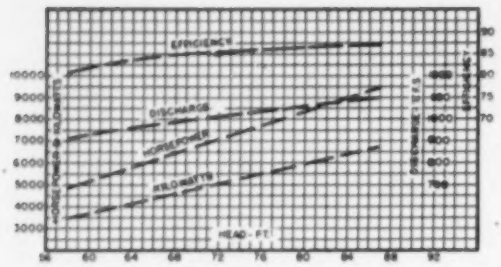

Fig. 3. Expected performance curves for pump turbine generating 9450 hp at 87 ft head, 163.6 rpm

it is connected. Where water storage and head conditions are favorable, there are probably a great many places in the United States where pump storage plants could be economically worked out especially if it could be assumed that a single pump-turbine unit is available for such applications.

The pump-turbine is a hydraulic unit with a single runner mounted on a shaft and enclosed in a casing with speed ring and movable guide vanes, see Fig. 1. It is designed so it can function as a centrifugal pump by being rotated in one direction, or as a hydraulic turbine by being rotated in the opposite direction. The pump is driven by a direct-connected electric motor and pumps water from a suction pool at a lower elevation to a storage reservoir at a higher level.

For generating power the flow cycle is reversed and water is allowed to flow from the storage reservoir through the pump-turbine and discharge into the suction pool. The same runner is now used as a hydraulic turbine and the motor, which is rotated in the opposite direction, is now used as a generator.

It should be noted also that as explained in the conference, the unit of Fig. 1, shown with a horizontal shaft, can be arranged equally well for vertical installation like a hydraulic turbine. This necessitates only the necessary mechanical changes in the supporting structure in the bearings and in the water passages. So far as the pump turbine itself is concerned, it makes no difference.

At the conference at Allis-Chalmers on June 1 the characteristics of the pump-turbine were reviewed first by W. W. Weltmer of the Allis-Chalmers' Centrifugal Pump Dept. Mr. Weltmer pointed out that turbine unit requires more head and capacity at its best point of efficiency as a turbine than it develops at its best point of efficiency as a pump. However, from the standpoint of head available from the external system the reverse is true. As a result it is not possible to utilize the maximum pump turbine efficiencies of the unit with the same external system. Introduction of variable guiding apparatus in the casing helps in the effort to make the characteristics of the pump turbine fit those of the external system. To further improve this fit, the Allis-Chalmers' engineers studied the design of a compromise unit.

They have built and are testing two identical pump turbine models as shown in Fig. 1. In the test setup, one model acts as a pump, supplying water to the other model which operates as a turbine driving a brake.

These tests are continuing and it seems that reliance must still be placed on the gates to improve the fit between the pump-turbine characteristics and those of the external system. There is, of course, another method and that is to pump and generate at different speeds. This would require the equivalent of a 2-speed electrical machine.

F. E. Jaski explained the operation of the machine and showed how at the start of the pumping cycle the suction pool is full and the upper storage reservoir is at its lowest level, hence we started pumping against the lowest head of the pumping period and gradually build up head to the upper limits which depend on the depth of the storage reservoir and the draw-down of the suction pool.

In generating power the net head on the turbine is the static head minus the friction loss in the system. We start generating power with the high head produced by a full storage reservoir and lowest level in the suction pool and the head then drops gradually to the minimum as the storage pond is drawn down and the suction pool is filled.

Discussing the various water and other conditions encountered, Mr. Jaski said it is assumed that the unit will be used in a fairly large power system which can supply power for pumping during the off peak period so that this power can be bought at low cost per kilowatt hour. The unit will generate peak power which can be sold at a much higher price per kilowatt hour and thus make the unit economically sound. The unit would not be used for regulating but would supply prime load on the system.

The curves shown in Fig. 3 illustrate what might be expected for a pump turbine generating 9450 hp for an 8 hour period.

Methods of starting the pump would depend on several conditions. One method would be to depress the water in the pump by compressed air to just below the runner and start the motor with the runner rotating in air. This would require the least load on the motor. The motor could then be started on reduced voltage if the in-rush current at full voltage should cause too great a disturbance on the system. After the unit is up to speed the air would be released and water allowed to rise in the pump until the runner is submerged, whereupon pumping could start and the guide vanes could be opened.

The turbine would be started in the conventional manner and put on the line. Then the guide vanes would be opened to the correct opening for generating the full capacity at the maximum head.

If the unit lost all its load for some fault on the system it would overspeed and eventually perhaps reach its full overspeed—if the closing time of the guide vanes was set for slow closing. The maximum overspeed would be approximately 47 per cent above normal speed at maximum head of 87 ft in the case of the unit discussed in Fig. 3. Generator motor and turbine would be designed to operate safely at 75 per cent overspeed and this, it is expected, would give ample margin over the maximum overspeed anticipated. It would save some cost as compared with the conventional hydro-electric generator which is usually designed for 100 per cent overspeed.

Pump-turbines can be built for heads comparable to those under which Francis turbines are used today. This range would be about 50 to 1000 ft head. Submergence of the unit is governed by the head used for pumping.

Application of electrical equipment to pump turbines was ex-

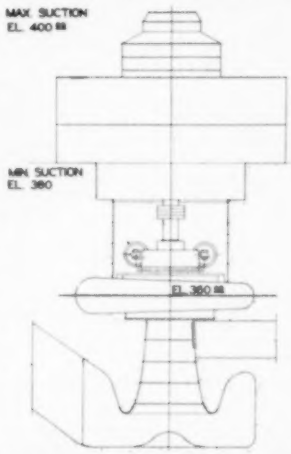

Fig. 4. Arrangement of power house pump turbine

Installation Techniques are "Pay-off" . . .

With modern operating temperatures ranging as high as 1050°F. and pressures climbing upwards of 2,000 psig., welding and concurrent heat treating of alloy power piping *during installation* pose critical problems for field crews.

For example, the weld shown in the illustration required a heat treating cycle of over 15 hours. During this time Kellogg crews, using special induction heating equipment, raised the temperature of the weld area at a predetermined controlled rate over a period of some four hours. Upon reaching the proper pre-heat temperature, welding was started as shown in the picture.

As the weld was made the temperature was naturally held at a uniform level. Upon completion, the weld was stress-relieved at a predetermined elevated temperature for over two hours and then allowed to cool at a controlled rate for four hours to complete the cycle.

Over the years such special techniques in connection with welding alloy piping have been developed by Kellogg engineers, who have been entrusted with such recent innovations in power piping as the first HT-HP stainless steel installation and the fabrication of piping for the original 1050°F. station.

The experience of these well-trained field installation crews is one "plus value" obtained when power piping by M. W. Kellogg is specified.

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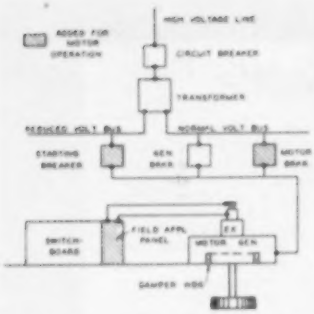


Fig. 5. Elementary electrical system for pumped storage hydro-electric power plant

plained in detail by W. L. Ringland, Electrical Dept., Motor and Generator Section. He pointed out that the chief differences between these units and a generating station arise from the necessity of starting and operating the synchronous machine as a motor with the direction of rotation opposite to that required when it operates as a generator.

The elementary electrical system for a pump storage hydro-electric plant is shown in Fig. 5. For the unit operating as a generator the conventional exciter, generator breaker, transformer and circuit breaker would be necessary. For the operation of such a unit as a pump-turbine unit the additional devices required are shown cross-hatched. These would include a starting breaker and a motor breaker and a field application panel, plus damper windings in the generator.

Since the plant would normally operate at the maximum power corresponding to the head available and would do little or no frequency or voltage regulating, need for a voltage regulator and a pilot exciter might be questioned. Amount of flywheel effect required in the unit might be reduced to the normal value because hydraulic regulating would not be critical.

The starting of the motor on such a pump turbine unit is the governing factor in designing such a unit and determines what equipment and starting procedure may be used. Minimum full-voltage starting kva of a motor suitable for these conditions would generally be in the range of 200 to 300 per cent. The limiting torque requirement is the break-away torque of the bearings if the pump is unwatered for starting.

To start these motors properly many of the more recent large pumping plants now in operation or under construction have control equipment for selective field application or "angle switching." This control connects the field circuit of the motor to its d-c supply at some particular favorable instant during the slip cycle after the motor has reached a sufficiently high speed during the starting period. The chief advantage is that approximately 25 to 50 per cent more load may be pulled into step as compared to field application at the least favorable instant during the slip cycle.

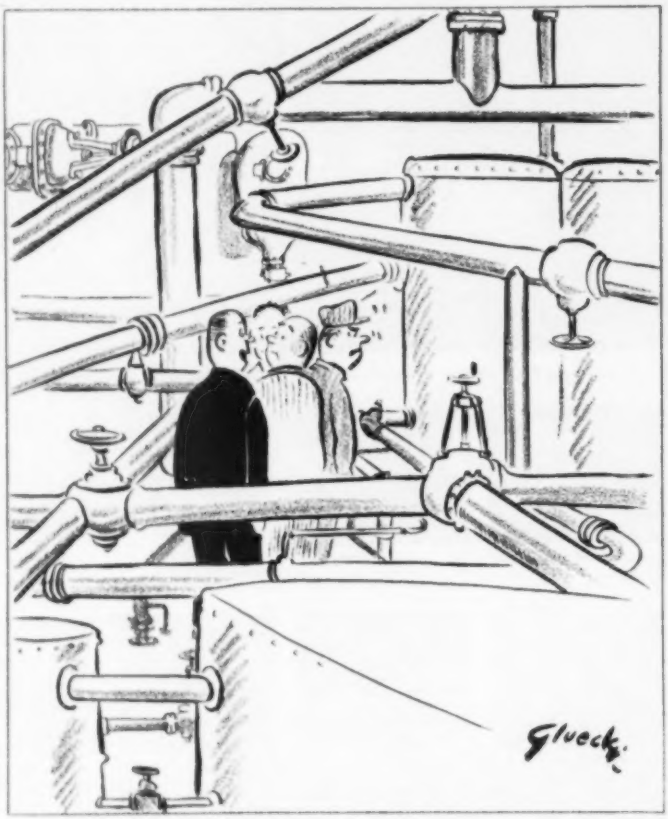
The major benefit of selective field application lies in avoiding the least favorable period which consists of about ⅓ of the slip cycle. This can be accomplished with the standard field application control at much less cost, although it may not be capable of adjustment to apply field at the exact optimum instant. Where a pump is started unwatered there seems little need for more than standard control.

Necessity for operating the machine in either direction presents no new problems in the design of the bearings. Large pump motors are usually required to operate without injury at reverse overspeed and bearings suitable for this requirement are in service in many installations.

The Kingsbury type of thrust bearing is inherently suitable for either direction of rotation. Each bearing shoe is supported on a spherical seat below the center of the shoe and adjusts itself in operation to the position governed by the oil film, regardless of the direction of rotation.

Guide bearings for the larger vertical pump motors are lubricated by two helical grooves in the bushings. One corresponding to a right-hand thread the other to a left-hand thread. Thus rotation of the shaft pumps oil upward in one or other groove depending on the rotation.

A number of the 30 prominent hydro-electric engineers attending the meeting discussed many of the above points with the speakers, then viewed a demonstration of the pump turbine models in the Allis-Chalmers' shops and attended a dinner in the evening. J. F. Roberts, Manager of the Hydraulic Department, was chairman of the conference and was assisted by H. P. Binder, Manager, Centrifugal Pump Department, and E. E. Ellis, Manager, Motor and Generator Section, Electrical Department. J. L. Singleton, Vice President and Director of Sales for the company, presided at the dinner as toastmaster.



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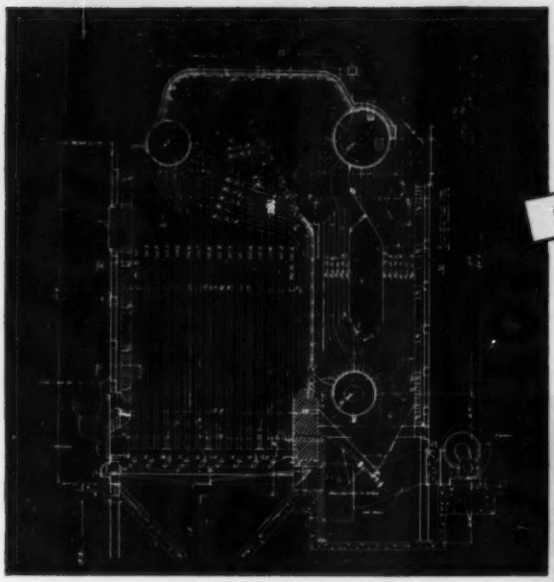

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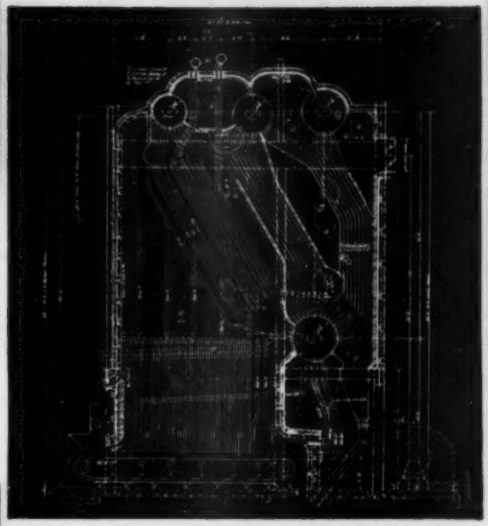

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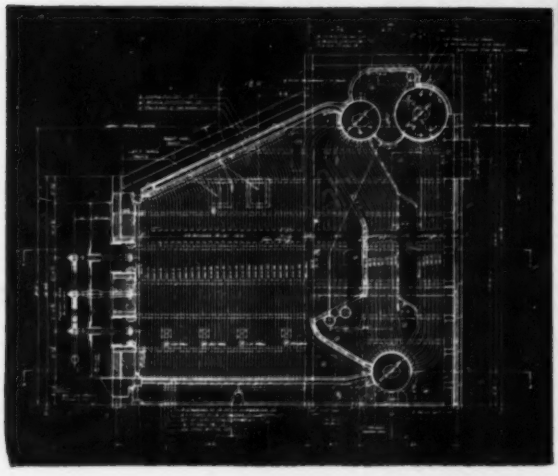

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What the Rectifier May Do for Railroad Motive Power*

By A. C. MONTEITH
Vice President in Charge of Engineering
Westinghouse Electric Corp.

FORTY YEARS AGO, when railroad electrification was rising in favor, Westinghouse transportation engineers visualized a possible answer to the problem of combining the advantages of alternating-current power transmission on the trolley with low-voltage direct-current motors on the driving axles. The answer they visualized was the mercury-arc rectifier, which had just come into being.

Early Rail Car Equipment

Putting action to idea, a rail car was equipped, in 1913, with a mercury-arc rectifier. The principle was sound but rectifiers had not been developed enough at that time to make this use practical. In short, the idea was ahead of its day.

So we shelved the idea. We didn't discard it—we just filed it away for the future. Meanwhile, we moved in the other direction to achieve the desirable objective of a locomotive with low voltage d-c motors operating from an a-c trolley through m-g sets.

Meanwhile, we never lost sight of the idea of using a rectifier, which is efficient and has no moving parts. Then in 1932, a much-improved ignitron-type rectifier was invented. During the recent war, this new rectifier was developed to such a high degree of reliability as a major source of direct current for the nation's aluminum and magnesium plants, that we felt the time had come to take the rectifier idea out of mothballs.

One day last July (1949) there rolled out of the shops at Wilmington a multiple-unit railway car equipped with d-c motors but with a-c power supply. Ignitrons converted the 25-cycle power from the 12,000-v overhead trolley to direct current for the two standard 225-hp d-c traction motors. The ignitrons in the car are standard—thousands of them are in industrial service.

Since last summer this car has been given extensive tests. The result has been ample evidence that the dream of four decades ago is practical.

* Abstract of a talk given March 16, 1950 before the New York Railroad Club.

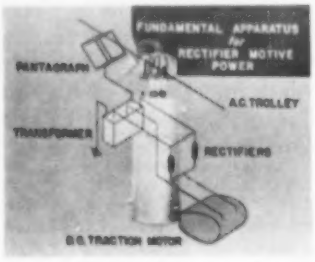

Fig. 1. Schematic diagram shows how a-c collected from trolley is first transformed and then rectified before going to d-c traction motors

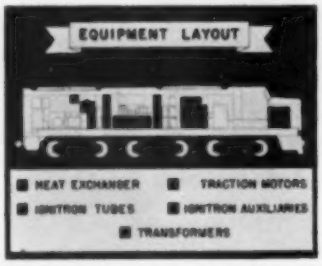

Fig. 2. Ignitron tubes and auxiliaries in middle of locomotive; transformer just forward of ignitron equipment; heat exchangers to the rear; additional auxiliaries forward of cab

Rectifier Locomotive

Westinghouse is now building two rectifier locomotives for the Pennsylvania Railroad. Each of these locomotives, made up of two self-contained units, will develop 6000 hp, each weighs 660,000 lb, has all weight carried on the twelve driving axles, and produces a maximum tractive effort of 165,000 lb.

Weight and space advantages of using rectifiers to effect the marriage of d-c driving motors with an a-c power supply are dramatically demonstrated by the fact that motor-generator equipment for a 6000-hp locomotive weighs four times as much as the rectifiers and their associated equipment. Furthermore, the motor-generators require longer and heavier locomotive cabs and running gear.

The fundamental operation of the rectifier locomotive is quite simple. Figure 1 shows the rectifier—which is 8 in. in diameter and 30 in. high—and its place in the locomotive equipment. Alternating current from the trolley is collected by a pantagraph in the normal manner and is

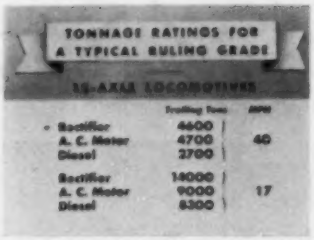

Fig. 3. Rectifier locomotive exhibits excellent tractive effort in low-speed, drag-zone and still maintains high-speed characteristics

then reduced to low voltage by a transformer on the locomotive. Between the transformer and motors are located the rectifier tubes that convert a-c into d-c power. The speed of the locomotive is controlled by varying the output voltage of the transformer.

Figure 2 shows how the rectifier equipment fits into the actual locomotives under construction for the Pennsylvania Railroad. Space required by the ignitron tubes is a very small percentage of the total. In fact, the equipment has saved so much weight that we are forced to add ballast to secure the adhesion necessary to fully utilize the capacity of the electric drive.

Merits of the Rectifier Scheme

Why add another distinctly different locomotive to the present large array that includes conventional steam, steam turbine, diesel-electric, trolley-electric, and a newcomer—the gas turbine?

The payoff for any locomotive is tractive effort. Weights and dimensions of typical rectifier and a-c locomotives are essentially the same, yet the rectifier lomocotive will be capable of producing continuously 47 per cent more tractive effort at low speed. This percentage increase in tractive effort can be translated into ability to haul trains. See Fig. 3.

Out of fairness to the locomotive with a-c motors, it should be brought out that its performance at high speed excels that of any locomotive. However it is deficient in the low-speed, drag zone. On the other hand, the rectifier type has very good low speed and starting performance, and still maintains high speed characteristics comparable to the a-c locomotive.

In addition, the rectifier locomotive's efficiency in converting trolley kilowatts to horsepower at the rail will be greater than is possible with the a-c design.

For the first time, electric motive power can be placed on a standardized, mass production basis. The rectifier tubes are now in commercial production and the traction motors are identical to the mass-produced Diesel motors. Many other parts of the locomotive can benefit cost-wise

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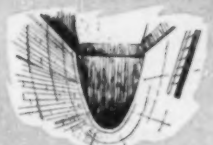

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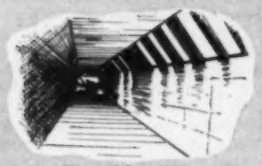

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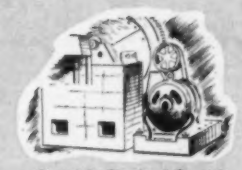

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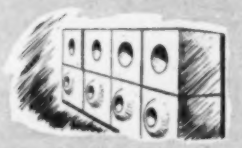

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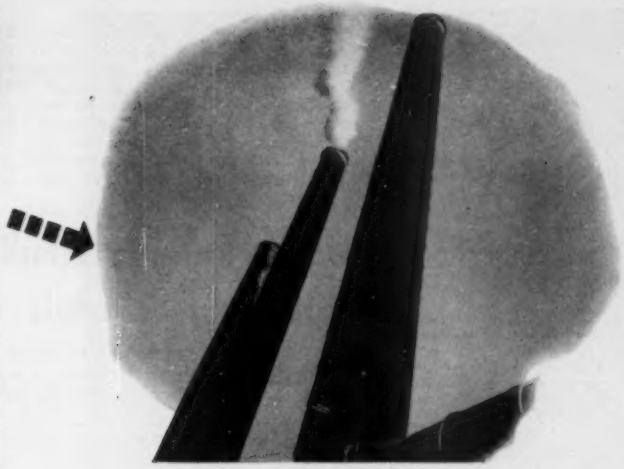

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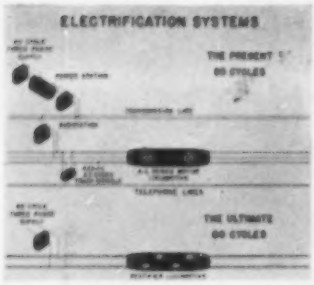

Fig. 4. Ability of rectifier locomotive to operate on 60-cycle alternating current removes many complications in railroad electrification. Equipment for present 25-cycle system compared with possible 60-cycle system

from use of standard apparatus and elements.

The low voltage, d-c traction motors which it uses require little attention. Broad experience with many rectifying equipments, which involve only static devices, indicates maintenance will be low.

Electrification Possibilities

The rectifier lomocotive will be put to good use immediately on the present electrified railroads because of its advantages of high tractive effort, greater efficiency, and reduced maintenance. In the future, it may have more far-reaching effects because of what it offers in the way of cost reduction—both its own cost and the railroad electrification cost. In fact, I may go so far as to say that it is quite possible that this new type of locomotive may be the key device by which the field of electrification will be widened to include many lines that cannot now economically justify it. This possibility is a consequence of another quality of the rectifier locomotive.

The rectifier lomocotive will relieve a-c electrification of the necessity of using 25-cycle supply, which is about the highest frequency for which a satisfactory alternating current series motor can be built. The commercial frequency is 60 cycles, so converting equipment or higher-cost generators were necessary for 25-cycle electrification. The rectifier system offers a means of eliminating this expense since a rectifier operates as well on 60 cycles as on 25 cycles. See Fig. 4.

Rectifier motive power removes the barrier to 60-cycle electrification. This fact, and the recent trend of railroads to accept standardized apparatus, stimulates fundamental thinking on further railroad electrification. The lower drawing on Fig. 4 portrays the ultimate in simplicity that might be attained. Since 60-cycle power can be used, all apparatus required can be of standard commercial type with a simple tie between the trolley and the power system, eliminating expensive conversion equipment. By using high trolley voltages auxiliary transmission lines and closely spaced substations can be eliminated. To reduce the changes necessary in signal and communication systems, it would be desirable to remove all locomotive current from the rails. This might be accomplished by using two trolleys.

Such a simplified system is a possible objective but by no means a certainty at this time. Even the approximate form of the results cannot be determined now. However, it is certain that the possibilities will be exhausted.

Utility Reserve a Full Year Ahead of Schedule

Seventh Survey of the Edison Electric Institute's Power Survey Committee shows a margin of 9,117,000 kw, or 15.6 per cent for 1950, one year earlier than anticipated

IN ANNOUNCING the 7th Annual Power Supply Survey results, Elmer L. Lindseth, President of the Edison Electric Institute, reported that the Institute's goal of an average of 15 per cent reserves of power production capability in the United States had been reached one year ahead of schedule.

Earlier surveys of the Committee indicated that the average reserve generating capacity for the country as a whole would reach 15 per cent in 1951. The seventh survey just completed shows a margin of 9,117,000 kw, or 15.6 per cent, for 1950, one year earlier than anticipated.

The actual margin of reserves in 1949 was 7,664,000 kw, or 14.2 per cent, the survey showed.

Only in two major areas and some localized areas will the estimated reserve figure for 1950 be below the 15 per cent mark—in the Pacific Northwest where a margin of 5.9 per cent under median hydro conditions is anticipated and in the Southeast where a figure of 8.2 per cent is expected. Only in the Northwest in case of drought is there any likelihood of a power deficiency requiring load curtailment. The present water conditions in that area are far above normal.

Briefly the survey shows for the U. S. the following percentage margins between generating capability and peak load demands:

1948	6.6 actual data
1949	14.2 actual data
1950	15.6 forecast
1951	18.9 forecast
1952	19.1 forecast
1953	18.6 forecast

Delivery time of heavy generating equipment has been reduced to two years, and if the need arises additional generating capacity can still be added in 1952 and 1953. Undoubtedly more will be added in 1953.

On V-J Day the total power producing capability of the industry in the U. S. amounted to 50 million kilowatts. This capability at the end of 1950 will be 67½ million kilowatts. With the expansion program of the industry still in high gear, capability will reach 83 million kilowatts in 1953, approximately a two-thirds increase in 8 years. The electric utility companies in this period will have added 28 million kilowatts of the 33 million kilowatts of additional generating capacity, or 85 per cent of the total added.

Although the 1950 margins of reserves are only about one-half the pre-war margins, that does not mean they are not generally adequate. There are three sound reasons for this difference. First, the substantial increase in interconnection and power pool operations during and since the war, covering as it now does most of the populous areas of the country, has made unnecessary the amount of reserves formerly required. The second reason is the great amount of new high efficiency, high load factor, equipment that has been installed, which requires less reserves. Third, prior to World War II employment was not at the high level now being experienced, which resulted in an abnormal high percentage of idle generating capacity for lack of power demand.

In considering the question of adequacy of electric power in the event of another war, it should be recognized that already we have added 50 per cent of new generating capability since the outbreak of World War II. If World War III were to come now, factories would go on two and three shifts per day, seven days a week, and they would switch from the production of civilian to war-time supplies. New generating capability could be built and interconnecting transmisison lines constructed substantially as fast as the average new munitions plant could be built and put into full operation. Limitations due to shortages of materials, manpower, and transportation for war production would again control, as in World War II, before the supply of electric power would become a critical factor.

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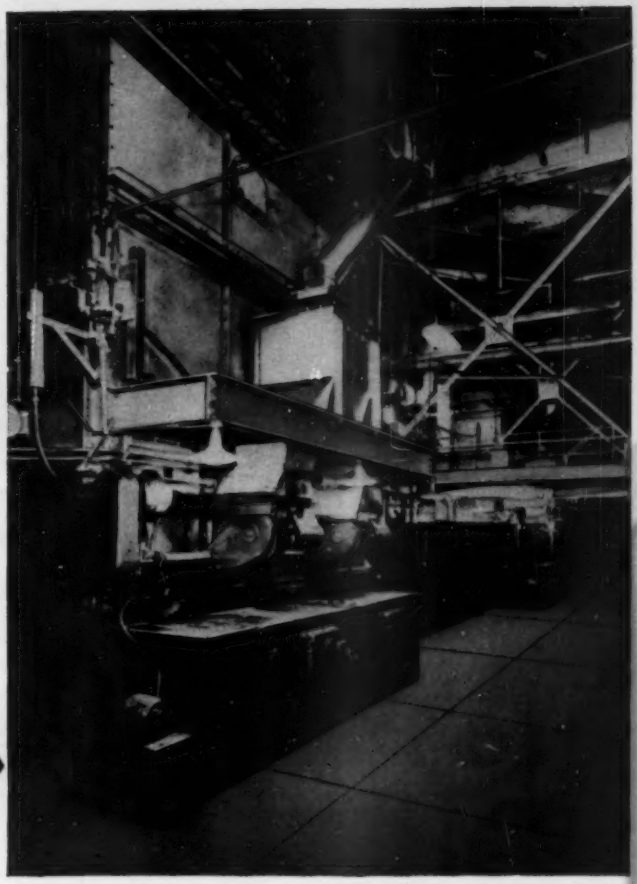

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New ENGINEERING BOOKS

Kent's Mechanical Engineers' Handbook, in two volumes. Volume 1, Design and Production, edited by Colin Carmichael; Volume 2, Power, edited by J. K. Salisbury. Twelfth Edition. Approximately 3000 pages, 6 by 8¾ in., flexible Fabricoid. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1950. Price $8.50 per volume.

Kent's handbook is so well known that to the older generation of engineers at least, this announcement of the new twelfth edition scarcely needs more than mention. For over 50 years this handbook has been the classic in its field; it has become the standard handbook of the mechanical engineering profession.

This handbook was first published in 1895. William Kent, following the advice of Nystrom, "that every engineer should make his own pocket book as he proceeds in study and practice in his particular business," had been collecting and arranging his notes and data for over 20 years. His original idea of a pocket book, however, soon gave way to more expedient means of accumulating data—the collection of indexed envelopes, portfolios and boxes, the card catalog, etc. In 1891 at the request of the publishers, Mr. Kent began to select the material on mechanical engineering and condense and arrange it for publication in book form. In this work, careful examination was made of the transactions of engineering societies and the most important work on mechanical engineering. The result was the first edition of "Kent's Handbook."

There is a great difference between the first edition of Kent's and this great new two-volume edition but the primary purpose behind the work remains essentially the same, to present all the essential data used in mechanical engineering as concisely and accurately as possible.

Kent's handbook ran through ten editions between 1895 and 1923. These were all one volume editions. In 1936, when the 11th edition was published, the expansion of the science of engineering made it necessary to divide the book into two volumes, one devoted to *Design and Shop Practice* and the other to *Power*.

This same arrangement has been retained in the publication of the new twelfth edition, except that now, the first volume is called, "Design and Production," and the second volume, "Power." The earlier title of Vol. I recognized the tie-in between the design engineering department and the shop. The new title underscores the fact that design and production are becoming recognized as two phases of a single activity—the engineering of a product from the inception of an idea to the completion of the finished article at an economical cost.

Volume I, *Design and Production*, has been edited by Colin Carmichael, editor of Machine Design, and Volume II on *Power* was prepared by a staff of specialists under the general supervision of J. K. Salisbury, Division Engineer, Thermal Power Systems of the General Electric Co.

Retaining the handy size and flexible binding of the previous edition, the new handbook has been completely rewritten in clear and accurate language. When we say rewritten, we mean exactly that, not merely a revision with only minor changes or additions. This new twelfth edition is completely different from the previous edition. Although much of the material from the 11th edition has been condensed, both volumes are now larger than their predecessors due to the necessity of presenting recent data and latest practices. A new index, carefully worked out by the editors, makes each piece of information doubly accessible. In the Kent tradition, the new edition stresses practice rather than theory. All the text and illustrative material used in earlier editions has been recompiled from the most thoroughly verified sources.

It is of course impossible in a brief review to give an adequate idea of what these two volumes contain but those familiar with the earlier editions will need little description. In the *Power* volume space given in the previous edition to steam engines, gas producers, and other less active subjects, has been devoted to the more modern and less widely understood subjects, such as atomic power, combustion gas turbines, supersonics, marine engineering, jet propulsion, aircraft piston engines, heat pumps, panel heating, diesel locomotives, electric locomotives, axial flow compressors, and instrumentation. The section on power test codes, extensive in the last edition, has been drastically cut to make room for other valuable reference material. Useful mathematical tables of the 11th edition have been retained for the most part, and amplified by important additions, including data on geometry and the calculus, differentiation formulas, and a table of integrals.

The most useful part of any reference book is the index and this has received much attention in this edition. Index entries guide the user to specific discussions as well as to broadly pertinent passages, and multiple page references direct him to the various shades of meaning. Each volume carries its own separate index. The index to the *Power* volume comprises 50 pages, that of the *Design and Production* volume, 49 pages.

Certain of the mathematical tables are duplicated in the two volumes. The section on logarithms, the table of common logarithms, the tables of the properties of numbers, the tables of trigonometric functions and the tables of weights and measures, will be found in both volumes.

The volume on *Design and Production* is directed primarily towards the engineers who design and manufacture machinery, appliances, mechanical equipment, and other engineered products. The 28 sections into which this volume has been arranged may be classified broadly as: Selection of materials (Sections 1 to 6); Design principles (Sections 7 to 9); Design and selection of machinery components (Sections 10 to 18); Production processes (Sections 19 to 25); Production plant equipment (Sections 26 and 27) and Mathematical tables (Section 28).

As in the case of the *Power* volume, the volume on *Design and Production* has been almost completely rewritten. New material required by progress in many fields has outweighed the obsolete material that has been discarded, resulting in a book more than 300 pages longer than the previous edition.

Much of the preliminary planning for this new edition of Kent was done by Robert Kent before his untimely death in 1947. More than half of the contributors had been given their assignments and were already at work on their sections when the new editors took over. The new editors have kept in constant view the objectives that guided both William and Robert Kent in preparing the previous 11 editions of this comprehensive handbook.

The quantity of physical and mental engineering effort that is represented by the information contained beween the covers of these two volumes is beyond comprehension; it involves untold thousands of man hours. Without question, these two volumes should be on the shelf of every engineer's library.

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Power Capacitors by R. E. Marbury, First Edition, 6¼ by 9½ in.; 205 pages, illustrated, cloth. Published by the McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York, N. Y., 1949. Price $3.50.

This book covers the fundamental working principles of capacitors, the materials used in the manufacture of power capacitors, and the characteristics of the completed units. It traces the history and development of power capacitors and their applications to power systems. The basis of rating power capacitors and their operating limitations are also covered, as are types of capacitors commonly manufactured and their respective fields of application. Selection and use of fuses and breakers to function with capacitor units, and the merits of different means of automatically switching capacitor banks with reference to system requirements are also discussed. Mr. Marbury, the author of this book, is manager of the capacitor section of the Switchgear Distribution Apparatus Engineering Department, Switchgear and Control Div., Westinghouse Electric Corp., East Pittsburgh, Pa. Mr. Marbury has been in engineering design work for this and other divisions since coming with Westinghouse in August 1917. During this period he has worked on the development and design of such devices as rectifiers, air conditioning, electrostatic precipitators, potential devices, lightning arrestors and capacitors. This book is the first volume to be published in the newly established Westinghouse-McGraw-Hill Engineering Books for Industry series. According to the publishers others will appear from time to time, all will have the same dark blue cover with title, author and publisher in gold on a red ink panel on the spine.

This book should help the industrial plant engineer to gain a better understanding of the significance of power factor and the gain to be made by the proper use of power capacitors to improve power factor. It gives the utility and operating and maintenance engineers useful information on the gains that can be realized by raising the system power factor or the power factor of specific circuits.

• • •

Diesel Engineering Handbook, 1950 Edition; revised by the staffs of Diesel Power and Diesel Transportation and Motorship; 725 pages, illustrated; size 6 by 9 in.; cloth binding; published by Diesel Publications, Inc., 192 Lexington Avenue, New York 16, N. Y. Price $5.00.

This is a new edition of this well-known handbook brought up to date. Because of the fundamental nature of the material included in previous editions, the principal revisions in this one have been the inclusion of outstanding new developments in the engine itself, its accessories and in the application of Diesel power. Inasmuch as the basic engine is applicable to all types of use—stationary, marine, railroad and other forms of land transportation—the contents of this handbook apply generally to all. A short chapter has been added covering certain points of interest, particularly in marine applications.

The first chapters of the book deal with details of engine construction, such as fuel injection systems, pumps and nozzles, frames and cylinders, pistons and rings, connecting rods, crankshafts, bearings, and so on.

There is a chapter on vibration isolation and others on engine air systems, governors, supercharging, fuel and lubricant handling, cooling water, exhaust and starting systems, and voltage regulators. The recently developed dual-fuel engine is well covered, also such details as flexible couplings, mechanical and hydraulic drives. The book is well indexed. It includes a section of advertisements of Diesel engines and their accessories and auxiliaries.

It should prove very helpful and usable for all Diesel engine operators and owners.

• • •

Heating, Ventilating, Air Conditioning Guide, 1950, 28th Edition; 1422 pages, illustrated; size 6½ by 9 in., cloth binding; published by the American Society of Heating and Ventilating Engineers, 51 Madison Ave., New York 10, N. Y. Price $7.50.

The fact that this is the 28th Edition of this famous book issued in 1950, indicates that it needs no introduction to engineers. It is one of the "bibles" of the field for anyone having heating, ventilating and air conditioning problems. It is revised each edition to incorporate the latest findings in various specialized divisions of the field.

This edition is divided, first of all, into several general sections as follows: 1. Fundamentals; 2. Human reactions; 3. Heating and cooling loads; 4. Combustion and consumption of fuels; 5. Systems and equipment; Special systems; 7. Instruments and codes; and finally a catalog data section containing data on specific products by various advertisers.

In the 28th edition for 1950, much new material has been added and the various sections revised to bring them completely up to date. The text on the physiological principles has been revised in accordance with the latest findings, also that on air conditioning in the prevention and treatment of disease and on air contaminants.

Chapter 10 on infiltration and ventilation is a combination of previous chapters on air leakage and natural ventilation plus added material. In Chapter 11 on heating loads, data have been added on floor heat losses in basementless houses. Rating formulas for forced warm air furnaces have been added to the chapter on heating boilers, furnaces and space heaters and the section has been enlarged and brought up to date. The chapters on chimneys and draft calculations have been largely rewritten. Data on mechanical warm air systems, hot water heating systems and piping, radiators and convectors have been revised.

In the chapter on air duct design, two charts replace the previous single chart for greater accuracy and complete range. Other changes, additions and revisions have been made in chapters on fans, refrigeration, motors and motor control, sound control, industrial air conditioning, drying systems, transportation air conditioning, water services and the codes and

standards have been brought strictly up to date.

An elaborate cross index is provided for the technical data section and also for the catalog data section.

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Engineering Papers of Hydraulic Institute, Volume II, by various authors; 62 pages, illustrated; size 8½ by 11 in.; paper binding; published by Hydraulic Institute, 90 West Street, New York 6, N. Y. Price $2.00.

In this publication, the Hydraulic Institute, trade association of pump manufacturers, publishes a group of engineering papers on pumps and pumping. The papers are all winners of awards in various engineering contests sponsored by Hydraulic Institute for the employees of its members, to stimulate their interest in the many and varied phases of the pump industry.

Section I of the paper is a discussion of Cavitation in Centrifugal Pumps by A. J. Stepanoff. This explains what cavitation is, how it is detected and what effects it produces, factors affecting it and how to avoid or reduce it.

Section II is a paper on the Centrifugal Pump in the Process Industries by A. T. Nielsen. This gives a history of the centrifugal pump, describes its structure in detail, and shows how to install it properly.

Section III is a paper on the Operation of Centrifugal Boiler Feed Pumps by Hans Gartmann. This discusses such things as suction pressure, necessity for maintaining sufficient flow through the pump, and pump balancing.

Section IV is a paper on Submergence for Centrifugal Condensate Pumps by Hollis T. Waldo. This gives details of tests run to determine the proper suction connections, size of suction and similar factors that must be considered to secure correct submergence and satisfactory operation of centrifugal condensate pumps.

• • •

ASTM Specifications for Steel Piping Materials, by ASTM Committee A-1 on Steel; 328 pages, illustrated; size 6 by 9 in., paper cover; published by American Society of Testing Materials, 1916 Race St., Philadelphia 3, Pa. Price $3.00.

This latest compilation of ASTM Standards on steel piping materials, as of December 1949, includes some 50 widely used specifications. Materials covered include: (1) Pipe used to convey liquids, vapors, and gases at normal and elevated temperatures, (2) Still tubes for refinery service, (3) Heat exchanger and condenser tubes, and (4) boiler and superheater tubes. To make the volume more complete there are also included specifications for the following materials used in pipe and related installations: (1) Castings, (2) Forgings, (3) Bolts, and (4) Nuts.

There are 16 pipe specifications covering seamless and welded; electric-fusion and electric-resistance-welded, and other types, in both carbon and alloy grades. Several specifications cover materials for service at high temperatures included autenitic pipe.

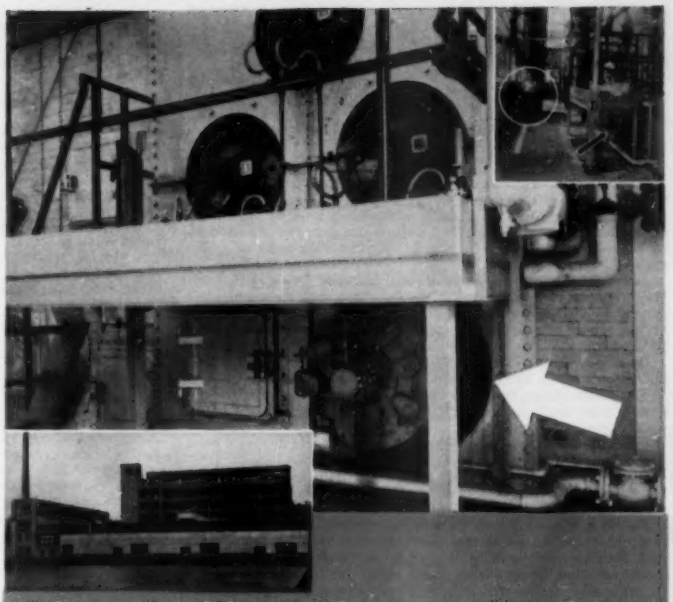
For boiler, superheater, and miscellaneous tubes there are 13 standards, including three for stainless tubing, ferritic and austenitic, for general service, and for sanitary tubing.

Three standards for seamless steel still tubes cover applications in refineries; and three other heat exchanger and condenser tube standards apply to seamless and electric-resistance-welded tubing of various grades.

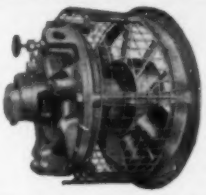
Various classes and grades of carbon and alloy-steel castings, forgings, welding fittings and bolting are included in 13 specifications. Many of the applications are for high temperature and high pressure service.

The publication is made more complete and usable by the Grain Size Standard E 19 and also by the American Standards covering steel and iron pipe (B 36.10) and the latest stainless steel document (B 36.19).

This is the latest authority on steel piping materials representing the work of Committee A-1 on Steel, with some 350 technologists serving on it. The recommendations of the Committee are submitted to the Society in accordance with a standard procedure; ample opportunity is given for everybody concerned to express their views and reach agreement. When approved the methods and specifications carry the full support of the Society. For that reason, everybody who has anything to do with specifying piping or piping materials should have thorough knowledge of the material contained in this publication.



Wing Turbine Blowers Combine Absolute Dependability With Complete Forced Draft Efficiency



Shown above is a typical Wing Turbine Blower installation serving one of the world's largest coffee packing plants. Note that the engineer (upper right photo) is able to talk on the telephone a few feet away from the Wing Turbine Blower—ample proof of its quiet operation. Write today for Bulletin.

In addition to these prime requisites, Wing Turbine Blowers have many extra money saving features including minimum cost of operation, simple, rugged, and compact construction, and because little or no duct work is required, no time or expense is required for engineering layout. Where plants can make use of the low pressure steam from the Wing Turbine Blower for such uses as feed water heating, process work, or space heating, the forced draft is obtained at negligible cost for power.

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AXIAL FLOW BLOWERS

POWER PLANT Construction News

Mobile, Ala.—Henderson Sugar Refinery, Inc., 749 South Peters St., New Orleans, La., plans boiler plant at proposed new cane sugar mill in vicinity of Mobile. Project will comprise several buildings for processing and general production, and is reported to cost about $4,000,000. Proposed to begin erection soon.

Burbank, Calif.—Burbank Public Service Dept., 174 West Magnolia Blvd., plans extensions in municipal steam-electric generating station, with installation of new turbine-generator, boiler and auxiliary equipment. Cost estimated about $2,500,000.

Durango, Colo.—Western Power Co., Newman Bldg., has authorized new hydroelectric power plant, with hydraulic turbine and generator unit for initial capacity of 6250. It is understood that station will be located in vicinity of other plants, near Tacoma, Colo.

Windsor, Conn.—Bd. of Selectmen, Town Hall, plans central-heating plant in new two-story and basement high school. Cost about $2,500,000. Bids are expected to be asked in near future. Ebbets, Frid & Prentice, 862 Asylum Ave., Hartford, Conn., are architects.

Palatka, Fla.—Hudson Pulp & Paper Corp., Southern Division, kraft paper products, plans extensions in power plant and facilities in connection with a large expansion and modernization program at local mill, for increased output in pulp and paper-making divisions, respectively. Cost reported about $10,000,000. Main offices are at 505 Park Ave., New York, N. Y.

Lawrenceburg, Ind.—Indiana & Michigan Electric Co., South Bend, Ind., will increase capacity of new steam-electric generating station on Ohio River, near Lawrenceburg, now in course of construction, and scheduled for completion in Feb. 1951. It will have a rating of 150,000 kw, and this capacity will be doubled with proposed addition, making a total of 300,000-kw for plant. Work on second unit will proceed in near future and is expected to be ready for service in Oct. 1952. Project will represent large investment, and will include extensions in power substations, transmission lines and other facilities.

Flint, Mich.—Bd. of Education plans central-heating plant in proposed new junior college, estimated to cost about $1,600,000. Financing will be arranged soon and detailed plans prepared.

Ypsilanti, Mich.—State Department of Buildings, Lansing, Mich., has plans maturing for new power plant at Michigan State Normal College, Ypsilanti, for central-heating service at institution. O'Dell, Hewlett & Luckenbach, Dime Bldg., are architects; E. R. Little Co., Kales Bldg., are consulting engineers, both Detroit, Mich.

Greenville, Miss.—Washington County Board of Supervisors, Greenville, plans central-heating plant in new county hospital, estimated to cost about $1,500,000. Proposed to begin work during summer. N. W. Overstreet & Associates, 201 North Lamar St., Jackson, Miss., is architect and engineer.

Moss Point, Miss.—International Paper Co., Southern Kraft Division, plans expansion in power plant at local mill, with installation of new 7500-kw turbine-generator, boiler and auxiliary equipment. Work will be carried out in conjunction with a general extension and modernization program at mill, to represent a large investment. No official estimate of cost announced. Main offices are at 220 East 42nd St., New York, N. Y.

Kansas City, Mo.—Fairbanks, Morse & Co., Inc., 600 South Michigan Ave., Chicago, Ill., is said to be planning boiler house at proposed new plant for manufacture of scales of all kinds, on site at Kansas City, now being acquired, totaling about 40 acres of land. It will comprise several production buildings. Entire project is reported to cost close to $5,000,000.

Henderson, Nev.—Harvey Machine Co., Aluminum & Brass Division, 19200 South Western Ave., Los Angeles, Calif., plans power plant at proposed new aluminum reduction works in vicinity of Henderson, consisting of several buildings, with furnaces and other facilities. Entire program reported to cost about $4,500,000.

Kenilworth, N. J.—White Laboratories, Inc., 113 North 13th St., Newark, N. J., pharmaceutical products, plans boiler house at proposed new multi-unit plant at Kenilworth, on which work will be placed under way soon. Entire project is reported to cost over $1,000,000. A. M. Kinney, Inc., 2905 Vernon Pl., Cincinnati, Ohio, is consulting engineer.

Thomson, N. Y.—United Board & Carton Corp., has approved plans for new power plant at paperboard mill, and will proceed with project at once. Proposed to have ready for service in fall. No estimate of cost announced.

Lumberton, N. C.—Robeson County Memorial Hospital, Inc., R. H. Livermore, president, plans central-heating plant in new hospital, estimated to cost about $1,250,000. Bids for erection will be asked in near future. W. W. Hook & Associates, 305 West 4th St., Charlotte, N. C., are architects.

Wilmington, N. C.—Woonsocket Falls Mill, Woonsocket, R. I., plushes and other textile products, plans boiler plant at proposed new branch mill at Wilmington, where site has been secured. Main mill will be one-story, 500x600 ft. Entire project estimated to cost over $3,000,000. Proposed to begin work soon. McPherson Co., 408 South Main St., Greenville, S. C., is architect and engineer.

Cincinnati, Ohio—Cincinnati Gas & Electric Co., Fourth and Main Sts., has plans maturing for first unit of new Clermont steam-electric generating station, and will begin foundation work soon. Project reported to cost over $10,000,000, with power substations, transmission lines and other operating facilities. Sargent & Lundy, Inc., 140 South Dearborn St., Chicago, Ill., is consulting engineer.

Cleveland, Ohio—Cleveland Electric Illuminating Co., Illuminating Bldg., has authorized an expansion in generating facilities during next six years (1950-55) to total 450,000-kw, comprising new plants and extensions in present power stations. This will provide an increase of 50 per cent in present gross capacity. Project is estimated to cost in excess of $125,000,000 in period noted, including power substations, transmission lines and other facilities.

Painesville, Ohio—Diamond Alkali Co., Inc., Union Commerce Bldg., Cleveland, Ohio, plans extensions in power plant at chemical works at Painesville, with installation of electric and steam-generating equipment for large increased capacity. Cost reported over $1,000,000. Project will be carried out in conjunction with a general expansion and modernization program, to represent large expenditure.

Oklahoma City, Okla.—Construction Service, Veterans' Administration, Vermont Ave. at H St., N.W., Washington, D.C., is asking bids until July 25 for boiler plant in connection with new hospital at Oklahoma City. Also for refrigerating plant, ail-conditioning system and other utilities. Entire project is reported to cost over $10,000,000.

Philadelphia, Pa.—Philadelphia Electric Co., 1000 Chestnut St., plans new addition to Delaware steam-electric power plant at Beach and Palmer Sts., to be equipped for a capacity of 250,000-kw, divided into two turbine-generator units, each of 125,000-kw rating, with high-pressure boilers and auxiliaries. Extensions will be made in switchyard, power substations and transmission lines. Proposed to have first unit ready for service in 1953 and second generator a year later. Cost reported about $45,000,000.

Pittsburgh, Pa.—Allegheny Ludlum Steel Corp., Oliver Bldg., electric and stainless steels, etc., plans extensions in power plants and facilities in connection with expansion and modernization in mills at Brackenridge and West Leechburg, Pa., to provide large increased output. Work will be carried out over period of 36 mos., with total cost reported about $23,000,000.

Covington, Tenn.—Town Council plans extensions and improvements in oil engine-operated municipal power station, with installation of equipment for increased capacity. Estimates of cost are being made.

Dumas, Texas—Potash Co. of America, Inc., Carlsbad, N.M., plans power house at proposed new plant near Dumas for production of potassium sulfate, sodium sulfate and kindred chemicals. Project will comprise several units for processing and general manufacture. Cost reported about $750,000.

Houston, Texas—St. Lukes Episcopal Hospital, 6265 Main St., and Methodist Hospital, 3020 San Jacinto St., plan joint construction of new power plant for service at institutional buildings. Cost reported about $700,000, with equipment. Watkin, Nunn, McGinty & Phenix, 5000 Caroline St., Houston, are architects and engineers.

Salt Lake City, Utah—Filtrol Corp., 634 South Spring St., Los Angeles, Calif., filtering, purifying and kindred products, plans boiler house at proposed new branch plant in vicinity of Salt Lake City. It will comprise several buildings for processing and general production. Entire project reported to cost about $$2,500,000.

Salt Lake City, Utah—Utah Power & Light Co., Kearns Bldg., will proceed with construction of new steam-electric generating station on local site, to be equipped for an initial capacity of 66,000-kw. Completion is scheduled during summer of 1951. Project will include new switching station and extensions in transmission lines.

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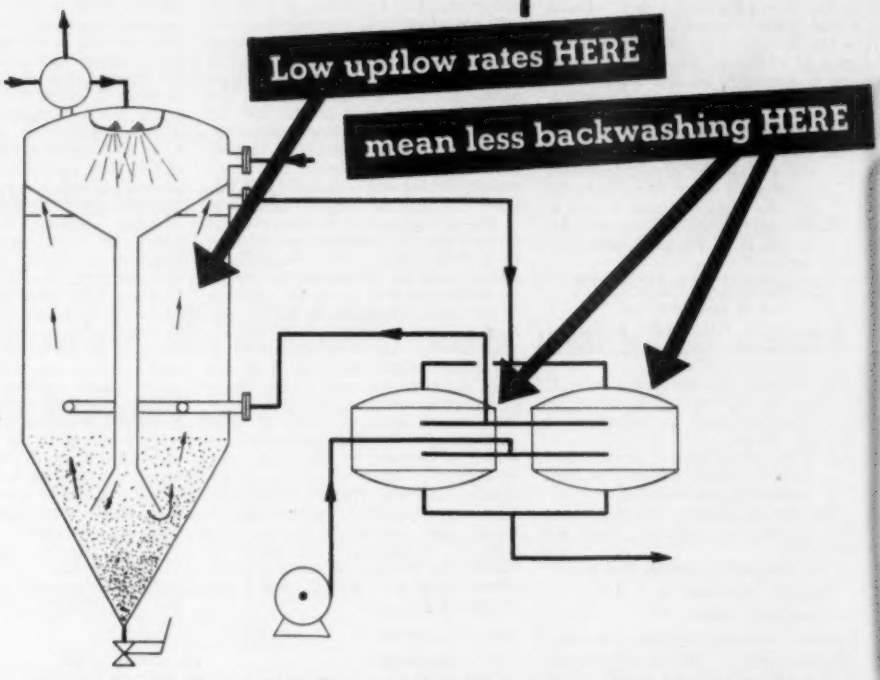

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DISSOLVED OXYGEN

(Continued from page 65)

with a Beckman pH meter. The description of their procedure is illustrative of modern practice. Titrate both the sample and the blank. The amount of $Na_2S_2O_3$ required is the total of:

1. Oxygen dissolved in the water sampled.
2. Oxidizing or reducing impurities in the water sampled.
3. Dissolved oxygen introduced by fixing reagents.
4. Iodine introduced with the iodized-alkaline iodine solution.

The titration of the blank amounts to the sum of 2 and 4 only. Items 1 and 2 are proportional to the size of the sample and are measured as ppm of dissolved oxygen. Items 3 and 4 are fixed by the analyst, do not vary with the sample volume, and should be measured as ml equivalent $Na_2S_2O_3$.

A. Subtract from the titration of the sample the pre-determined equivalent ml of thiosulfate for for the sum of items 3 and 4.

B. Multiply the difference obtained in A above by the factors:

$$\frac{\text{normality of } Na_2S_2O_3 \times 8000}{\text{vol of sample in ml}}$$

C. Subtract from the titration of the blank the $Na_2S_2O_3$ equivalent of item 4.

D. Multiply the difference from C by the corresponding factor for the flask used in collection of the blank.

E. The value from B minus that from D equals ppm of dissolved oxygen in the sample.

For the laboratory method use a 500 ml sample, and the following reagents:

$MnSO_4.4H_2O$, 480 gm per liter;

H_2SO_4, 750 ml. in 1 liter;

$Na_2S_2O_3$, 0.05N;

Iodized alkaline iodide. Dissolve 700 gm KOH in 700 ml water, and to this add 150 gm KI in 200 ml of water, wash 0.03 gm iodine into the solution, and dilute to 1 liter.

Evans and Simmons (16) studied the potentiometric titration of iodine in small concentrations and its application to the determination of dissolved oxygen in de-aerated water. When a constant small potential is applied to two clean platinum electrodes in $Na_2S_2O_3$ a back emf is set up which rapidly becomes equal but opposite in sign to the applied potential. The galvanometer then registers zero current. As $Na_2S_2O_3$ is a reducing agent there is little or no polarization of the cathode alone. If sufficient iodide ions are present these will depolarize the anode. This state continues during the titration, and the galvanometer spot rests at zero except for small temporary excursions which occur immediately after adding each drop of iodine. At the endpoint the slightest excess of free iodine causes a permanent partial depolarization of the cathode with a resultant fall in the back emf of the system and a small but permanent deflection of the galvanometer in the expected direction. The end point is readily determined to $\pm$ 0.01 ml of 0.002 *N* solution or 0.0005 ml oxygen per liter.

B. Electrometric Titration for Schwartz and Gurney Modification

Potentiometric titration has also been used for the Schwartz and Gurney procedure or for its subsequent modifications. Ulmer, Reynar, and Decker (62) collected two 250 ml and one 500 ml samples simultaneously by means of a three-arm manifold, and titrated them by the "dead stop" endpoint, using bare platinum electrodes. One ml of manganous sulfate and one ml of alkaline iodide are added to the 500 ml sample and one of the 250 ml samples. If the solution is reducing, indicated by the absence of deflection in the galvanometer, the titration is carried out with 0.002 N KIO_3 until the first permanent deflection of the galvanometer is observed. If the solution is oxidizing as indicated by a deflection, 0.002 N $Na_2S_2O_3$ is added until the galvanometer shows no deflection and then the solution is titrated with 0.002 N KIO_3. Use 3 ml HCl instead of the 2 ml usually specified in the Winkler titration. By always approaching the endpoint from the reducing side a very sharp endpoint is obtained, easily discernible with 1 drop of 0.002 N KIO_3 or 0.003 ppm O_2. The galvanometer, which is affected by vibration, may be replaced by an electron ray indicator, and amplifier, or magic eye. The net thiosulfate of sample A minus that of sample B, item 1—item 1^1, is equal to the dissolved oxygen in 250 ml of sample, since items 2 and 2^1, 3 and 3^1, and 4 and 4^1 cancel out.

Item	Sample A	Item	Sample B
	500 ml fixed		250 ml fixed + 250 ml not fixed
1	Dissolved oxygen in 500 ml sample	1^1	Dissolved oxygen in 250 ml sample
2	Contaminants in reagents	2^1	Contaminants in reagents
3	Thiosulfate added, if not already reducing	3^1	Thiosulfate added, if not already reducing
4	Reducing or oxidizing agent in 500 ml sample	4^1	Reducing or oxidizing agent in 500 ml sample

Sillars and Silver (56) recommended electrometric titration and state it is better to add an excess of 0.004 N $Na_2S_2O_3$ and back titrate with 0.002 N KIO_3 solution.

Sebald (53) employed potentiometric titrations, with platinum and calomel electrodes, in a comparison of the U.S. Navy modification of the Schwartz and Gurney "A" test, the Schwartz and Gurney "B" test, and the standard Winkler test. The U.S. Navy modification of the Schwartz and Gurney "A" test is the procedure of Adams, Barnett, and Keller (1), and this was found by Sebald to be the most satisfactory. Janssen (31) also note that the U.S. Navy method was the most accurate and precise procedure for dissolved oxygen, having an error of less than 0.001 ml per liter.

Non-iodometric Procedures

Various procedures have been proposed for dissolved oxygen which do not involve the use of iodine. Anderson and Dickson (6) used the reaction between alkaline tartrate, methylene blue, and standard ferrous ammonium sulfate for the determination of dissolved oxygen. The end point was indicated by the disappearance of the blue color. The ferrous solution was standardized against distilled water of known oxygen content made by shaking water with air till saturated at a known temperature and referring to tables for the quantity of dissolved oxygen present. Siegert (55) dissolved the precipitated manganese carbonates, without removing the precipitate from the supernatant liquid, with H_2SO_4 and oxalic acid, heated, and titrated directly with $KMnO_4$. He claimed good agreement with the Winkler method. Muller-Neugluck (39) also found this procedure an effective substitute for the Winkler method using KI. Sharp, Hand, and Guthrie (54) showed that in water and milk a procedure, depending on the quantitative oxidation of ascorbic acid in the presence of ascorbic acid oxidase by dissolved oxygen, gave good agreement with the Winkler procedure. Leithe (35) treated 250 ml of water in a flask with 5 ml of 0.1 N ferrous sulfate and 0.6–0.8 gm KOH. The precipitate was allowed to settle and then 5 ml of 50 per cent by weight H_2SO_4 was added. The sample was transferred to a larger flask and the excess ferrous ion titrated with 0.1 N $KMnO_4$. On the whole these procedures do not appear to be adapted for the determination of the very low concentrations of oxygen occurring in boiler waters.

Effect of Sulfites

Several workers have discussed the determination of dissolved oxygen in the presence of sulfites. Theoretically, dissolved oxygen and sulfites cannot be present simultaneously in a water, but in practice it may be possible for them to do so. Gol'dina (22) added NaOH, $MnSO_4$, and $KHCO_3$, filtered off the precipitate and washed it in $KHCO_3$ solution, dissolved it in HCl, added KI and starch, and titrated as usual. Hofer (28) reported that it was impossible to determine oxygen in sul-

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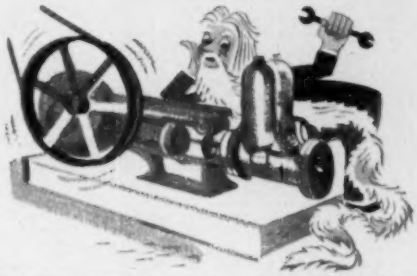

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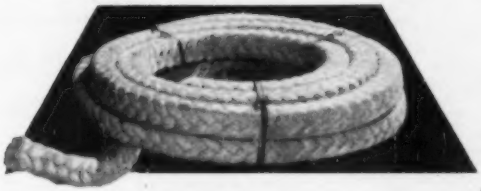

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fite-containing water, since slight amounts of oxygen produce no appreciable coloration of the manganese precipitate in the Winkler test, and the reactions resulting from acidification have no significance in the presence of sulfite. Janssen (30), however, stated that the Winkler method could be used without modification, the Mn^{++} of the added $MnCl_2$ acting catalytically in the oxidation of the sulfite by the dissolved oxygen and these combining in equivalent amounts.

Influence of Starch

The effect of starch on the determination of dissolved oxygen has been investigated. Yoder and Dresher (69) found wide differences in sensitivity of various starches and concluded that while an arrowroot starch might be slightly more sensitive at higher temperatures than a soluble starch, soluble starches should be used in preference to arrowroot and other insoluble starches. The latter tend to adsorb iodine, necessitating extreme care to avoid over-running the end point. In any case the sample should be cooled, so that the advantage of arrowroot starch at higher temper-

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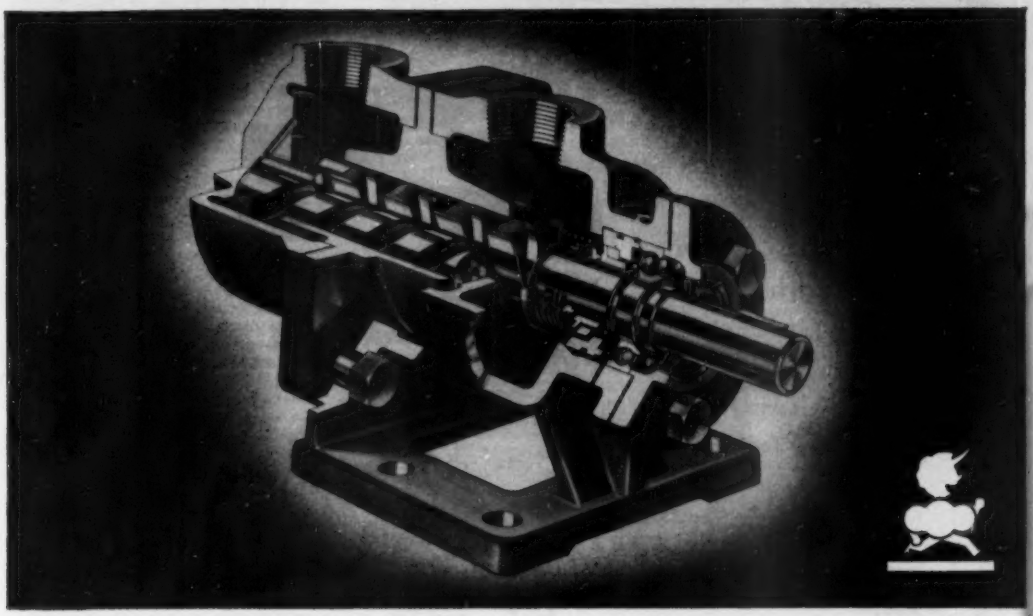

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atures is not a practical consideration. Platner (47) recommended adding 20 per cent NaOH solution with stirring to 2 gm powdered starch in 300-400 ml water until a thick, sirupy, nearly clear solution is obtained. After allowing to stand one hour it was neutralized with HCl. One ml of glacial acetic acid was recommended as a preservative. Pinkney and Young (45) examined the sensitivities of a number of starches at temperatures ranging from 33 to 105 F to determine the optimum temperature conditions for the starch-iodine reaction in the Winkler test for dissolved oxygen at low concentrations. The starch-iodine reaction was found to have its maximum sensitivity at a temperature of approximately 50 F. Above this point the color complex is increasingly unstable; below this temperature the reaction rate of iodine solutions is too slow for industrial analyses. Owing to the practical difficulty of cooling samples to the required temperature it is suggested that the final titration be made potentiometrically, or the modifications proposed by Schwartz and Gurney may be employed.

Peat, Bourne, and Thrower (42) have suggested the use of sodium starch glycollate 1:10 as an indicator in iodometric analysis. It is soluble in cold water, completely stable, does not form a water-insoluble complex with iodine, and it gives a very sharp, reproducible end point in dilute solutions.

We have tried this indicator in dissolved oxygen work at Nchanga, but found that with 0.005 N $Na_2S_2O_3$ a consistently earlier end point was obtained, giving slightly lower results than secured with ordinary starch or potentiometric titration. For the latter we employed both the usual potentiometric titration with platinum and calomel electrodes, and the "dead stop" technique with two platinum electrodes.

Effect of Temperature

The influence of temperature on the sensitivity of the starch iodine reaction has been studied by several investigators. Yoder and Dresher (69) stated that the temperature should not exceed 85 F. Alfano (2) recommended that the sample should be cooled as much as possible, preferably to 40 F. Bond (10) quoted 70 F as the maximum permissible temperature, and the American Public Health Association and American Water Works Association (5) advise that boiler waters should be cooled at 70 F during sampling. Pinkney and Young (45) observed that starches showed a maximum sensitivity in the neighborhood of 50 F, for the reasons outlined in the previous paragraph—a balance between slow reaction rate at lower temperature and unstable color complex at higher temperatures.

Effect of Concentration of Iodide

Pomeroy and Kirschman (48) found that the use of increased quantities of iodide in the Winkler procedure for dissolved oxygen diminishes interference by organic matter, reduces loss of iodine vapor, and sharpens the end point of the titration. Instead of the hydroxide-iodide solution usually specified for this analysis which is 12.5 N in alkali and 0.9 in iodide, they recommend one which is 10 N in sodium hydroxide and 6 N in sodium iodide.

Use of Tablets

To simplify the Winkler procedure for routine tests by non-chemical personnel, some of the reagents have been occasionally prepared in tablet form. Sander (51) reported the results of six years' work with solid tablets of $MnCl_2$ weighing 1.5 gm and similar tablets of KOH. One tablet of $MnCl_2$ and six of KOH were sufficient for a flask of 250-300 ml. Recently Killner (33) described a method designed for carrying out dissolved oxygen tests on ships by engineers without chemical experience. The reagents are in tablet form, dispensing with burettes and standard solutions. The contents of the kit include a sampling bottle of 600 ml capacity with a graduation mark at 500 ml and an angled stopper, glass rods and pestles, rubber tubing, reagent bottles containing sulfuric acid and starch solution, and tablets of manganese sulfate, potassium iodide, potassium hydroxide, sodium thiosulfate, and starch. Each tablet of sodium thiosulfate used represents 0.02 ml dissolved oxygen per liter.

Removal of Dissolved Oxygen

The removal of dissolved oxygen from water has been discussed by several investigators. Winkler (67) swept out oxygen from water by a stream of carbon dioxide. Dissolved oxygen recorders usually depend on a stream of hydrogen to carry any oxygen in the water through a thermal conductivity cell (27). Haslam and Moses (25) stated that the best way to free water of dissolved oxygen was to sweep it with a stream of nitrogen. Patrick and Wagner (41) recently removed oxygen from water by bubbling nitrogen through the water which is in contact with molten Wood's metal alloy. After three hours' refluxing the water is siphoned off under nitrogen pressure.

Pinkney, Dick, Douglas, and Young (46) attempted to duplicate work reported on the elimination of dissolved oxygen by passing an electric current through boiler feedwater, but could not reduce the dissolved oxygen content electrically. They believe that electrical deaeration involves an electrolytic reduction of one of the constituents of the water, and that this reduced substance consumes dissolved oxygen in the feed-water. Moreover

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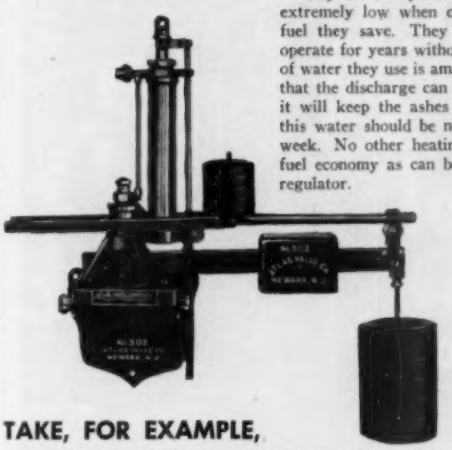

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this agent seems to leave sufficient residual to react with the iodine released decomposition of potassium iodide which normally occurs in a completed Winkler test solution on standing. They feel that electrical de-aeration is not universally applicable and depends on the salts in the feedwater.

As a result of the large amount of experimental work done for many years on the determination of dissolved oxygen in water, it appears that the best procedures for the small quantities occurring in boiler waters are potentiometric. These may take the form of the U. S. Navy modification of the Schwartz and Gurney procedure with platinum and calomel electrodes, (1, 53), or the methods employing two platinum electrodes and titration to the "dead stop" end point (16, 62). For field work, where a potentiometric titration assembly is not available, titration to the visual starch-iodide Gurney "A" procedure (14, 52, 53) end point, using the Schwartz and is recommended.

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(Continued from page 72)

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Exhaust gases turn the turbocharger and then vent through vertical silencers on the roof. Each silencer is jacketed so that in cold weather engine air can be warmed before it is drawn through the oil bath filters in the engine rooms to the turbocharger which supplies air under pressure to the cylinders on the intake stroke of the pistons. This supercharging results in a 50 per cent increase in engine horsepower rating.

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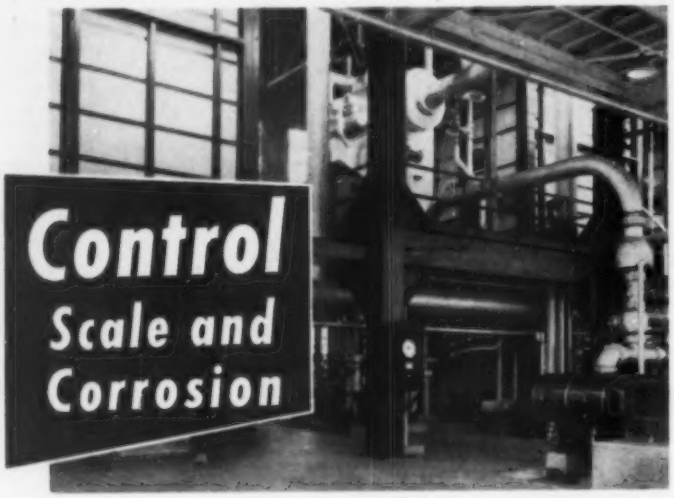
Each engine with its generator and exciter is mounted on a floating concrete slab supported by 16 vibro-isolators (each with nine springs) and four mechanical snubbers. Flexible joints are included in the exhaust, intake air, oil and water piping.



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TECHNICAL KNOWLEDGE

(Continued from page 8)

think it can be shown that our failure to recognize and respond to our broad responsibilities as citizens and human beings, our failure to understand that technical progress is not enough, is the key to many of our greatest difficulties in America today.

You and I hear and take part today in a lot of conversation about how we can stop the trend toward socialism in America. If I am sure of anything, I am sure that we can't stop the trend toward socialism by talking about it, or by talking about all the evils it has led to elsewhere and may lead to here. Nor is it certain that we can stop it altogether by replacing one set of elected government officials with another, however desirable that may be for other reasons, because essentially the trend arises not alone from the will of our elected and appointed officials but from the will of a people seeking justice, tranquillity and the general welfare, and not knowing how to find these desired ends.

Actually, of course, these ends cannot be achieved through socialism, any more than they can be achieved through any other mere

doctrine. If they can be achieved at all it must be done instead through effort. This means that we must turn some of our attention away from technical progress to insure the survival of our economic society as we know it.

There are a few hopeful signs that this is being done. Increasingly we find the leaders of our technical society, people like yourselves, turning away from their professional and business lives and accepting responsibilities in the education and welfare activities of the community. Increasingly too, we see technical leaders assuming political responsibilities—and it is in this area, I think, that our failure as citizens has been most shameful. Until we have done this and much more, how can we expect a political system based on the sovereignty of the people to work?

Our greatest hope for the future, however, lies in the evidence of still another awakening interest in our technical society—an interest in spiritual and moral as well as technical values. Church memberships are growing as people reach out for something they are aware is missing in their lives. Books whose message is a spiritual message are on best-seller lists for the first time in our history, and this is especially important, I think—these books are in greatest demand on our college and university campuses. Here again, however, it is our technical leaders on whom we must depend to give the movement toward spirituality a strength and vigor and endurance that will make it meaningful. Can you turn aside from technical progress to contemplate the greatest and most neglected admonition that has ever been given to man: "Love thy neighbor as thyself?" If you can, we will find our way out of the difficulties we are in and any others that may come to us. If you cannot, surely we are doomed.

On the Nationalist war front in China, in a mission hospital, a nursing Sister was tenderly caring for a dirty Chinese soldier whose ugly, festering wounds were an offense to the senses. A war correspondent in the ward looked on for a moment, and said: "Sister, I wouldn't do your work for a million dollars!" The Sister looked up and smiled, then replied "Neither would I."

Yarnall-Waring Company announces the following appointments: Lytton C. Musselman in charge of Los Angeles district at company office in Huntington Park, California; Power Engineering Company as general sales representative in Salt Lake City; Wallace J. Agren as sales engineer in Chicago branch, replacing F. C. Harry Vaughan, deceased; R. W. Westlake as sales engineer in Cleveland branch; Andrew M. Ritter, district manager of Detroit branch.

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The method is similar to that used in other conventional industrial filtration operations. A small amount of Sorbo-Cel (a specially processed diatomaceous silica powder), is added to the water to be filtered. This is then pumped through a pressure filter where the oil globules are adsorbed by the specially treated Sorbo-Cel particles. Both are retained on the filter screen, the filtered water alone passing through. Any type of pressure filter having a metal screen and capable of operation at a pressure differential of 30 psi or more may be used.

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PG-7

CONSTRUCTION OF SHORT CIRCUIT CURRENT DECREMENT CURVES

(Continued from page 69)

"Times Normal" fault current $= \frac{100}{X_e}$

For all practical purposes this component disappears in four or five cycles.

12. Plot the values of fault current obtained from Steps 10 and 11 in "times normal" base current, or amperes if preferred, using values of Fault Current as ordinates and Time After Short Circuit as abscissa. The final step is to draw a smooth curve through the plotted points with the subtransient reactance portion of the fault current curve merging with the transient reactance portion at about five cycles after the instant of short circuit.

The decrement curves for single-phase line-to-line and line-to-ground faults are constructed in the same manner as the three phase curves, using values of initial symmetrical fault current obtained from the following formulae:

Single Phase $I_{sc} = \frac{100\sqrt{3}}{X'_d + X_2}$

Line-ground $I_{sc} = \frac{3 \times 100}{X'_d + X_2 + X_o\ (*)}$

*Except in the case of Y-Y transformer grounded on both sides (seldom used), a transformer interrupts the zero-sequence reactance circuit. Therefore, the X_o of the system on the power-source side of a transformer should not be included in calculations of line-ground fault currents on its load-side.

Rotating machine reactance data should be obtained from the Design Engineers rather than using the average values given in tables, because the difference between the actual and the average values could be enough in some cases to make a substantial difference in the final results.

Ohms reactance and resistance for transmission lines, cables, etc. can be obtained from any of the various tables available.

$\%X$ or $\%R$ of transmission lines $= \frac{\text{Base Kva} \times \text{ohms per phase}}{(\text{kv})^2 \times 10}$

Symbol Definitions

- I_{sc} = Short circuit current, time normal base current.
- X_d = Generator synchronous reactance, per cent.
- X'_d = Generator short-circuit transient, per cent.
- X''_d = Generator subtransient reactance, per cent.
- X_e = Total reactance of system external to generator, per cent.
- R = Resistance, per cent.
- Z = System impedance = $\sqrt{X^2 + R^2}$, per cent.
- T'_{do} = Generator field time constant with armature open circuited, seconds.
- $T'_d = \frac{X'_d + X_e}{X_d + X_e} T'_{do}$ = generator field time constant with armature connected to external reactance X_e, seconds.
- X_o = Zero-phase-sequence of that portion of the system metallically connected to the faulted circuit, per cent.
- X_2 = Negative - sequence - reactance = X''_d for generators, and X for transformers, lines, etc., per cent.

Following is a table showing the Approximate Relation Between Zero and Positive-Phase-Sequence Reactances to use in making line-ground fault calculations.

Apparatus or Circuits	Ratio of Zero-phase to Positive-phase Sequence Reactance X_o/X_p
Wye/delta transformer with grounded neutral	1
Current-limiting Reactor in three-phase circuit	1
Neutral Resistor or Reactor*	3
Transmission Lines	
Single-circuit	
No ground wires	3.5
One ground wire**	2.75
Two ground wires**	2.25
Double-circuit on same towers	
No ground wires	6.0
One ground wire**	5.0
Two ground wires**	4.0
Double-circuit on separate towers but on same right-of-way.	
No ground wires	5.0
Two ground wires—1 per circuit**	4.5
Four ground wires—2 per circuit**	3.5
Cables	
3-phase	3 to 5
Single-phase	1

* Neutral resistance R must be added vectorially to X_o of system.

** Copper, ACSF, or copperweld high-conductivity ground wires are assumed. If steel ground wires are used, reactance values will approach those for arrangements with no ground wires.

LETTERS TO THE EDITORS

(Continued from page 53)

storage tank which can be filled from the make-up and draw-off tank as additional condensate is fed into the system by the evaporators, and can be drawn upon whenever the level in the make-up and draw-off tank gets too low.

For a final question, is No. 1 heater inside the discharge from the low pressure turbine to the condenser?

HOWARD T. LIVINGSTON
Mech. Engineer
Dept. of Water & Power
Los Angeles, Calif.

Mr. Yeager Replies

MR. LIVINGSTON is right, the description of the feedwater cycle in my article on Miami-Fort Station could have been written with more clarity so that it would have been easier to follow, at least to one entirely unfamiliar with the station. However, the feedwater cycle at Miami-Fort is by no means unique and it employs a conventional arrangement that is very familiar to power plant operators.

Mr. Livingston feels that the Design Performance Diagram of Unit 5 lacks completion. This diagram, however, is perfectly standard and is intended to show only the main components of the unit in a schematic fashion, giving the pressure, temperature and flow-rate of water and steam at major points as calculated by the designers for a given load.

In the second paragraph on the feedwater cycle the only tanks referred to are the overhead distilled water tank and the miscellaneous drain tank. The overhead distilled water tank is located above the high pressure heaters as shown in Fig. 6. The miscellaneous drain tank is located in the condenser well, labeled distilled water recovery tank. The deaerator storage tank is a part of the deaerating heater and not a separate hot water tank. All condensate drains flow to the miscellaneous drain tank. An uncontrolled overflow pipe is provided to dump excess water to waste from the tank. Liquid level control over a wide range is maintained at the tank to pump water normally to the overhead distilled water tank.

The deaerator storage tank is equipped with three liquid level controls. Normal level changes between fixed limits allow water to flow from the overhead distilled water storage tanks to the condenser through a level controlled valve. High water in the deaerator storage tank operates a second liquid level control to open a valve in the condensate line ahead of the low pressure heater allowing excess water to flow from the cycle into the overhead distilled water tank. A third liquid level control operates a dump valve in the emergency high water overflow line on the deaerator storage tank for dumping water to the miscellaneous drain tank. The boiler feed pump suction is equipped with an emergency cold water suction line from the overhead distilled water tank. This function is manually operated.

The No. 1 heater or low pressure heater is installed vertically along side the turbine exhaust stack and not in the stack. The heater is shown in dotted lines in Fig. 2.

No. 4 heater and No. 3 heater have been interchanged due to a copy error. No. 4 heater drains to No. 3 heater and No. 3 heater drains to the deaerating heater as shown on the heat balance diagram.

B. J. YEAGER,
Electric Production Dept.
Cincinnati Gas & Electric Co.

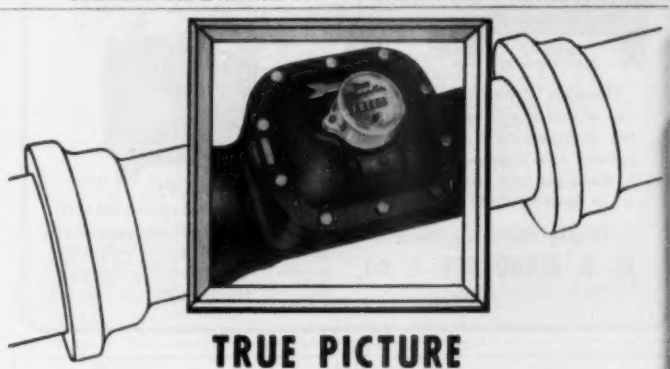
YOUNGSTOWN'S NEW BOILER

(Continued from page 61)

for further purification before being passed into the control apparatus. Since control engineers are well agreed that dirt and moisture in control air is one of the principal causes for malfunctioning of control equipment, it was considered worthwhile to take all possible precautions to provide this control with clean operating air.

When the boiler is burning blast furnace gas the automatic combustion control system operates the butterfly valves in the gas supply lines to the burners to supply the required fuel to maintain the steam pressure.

The automatic combustion control



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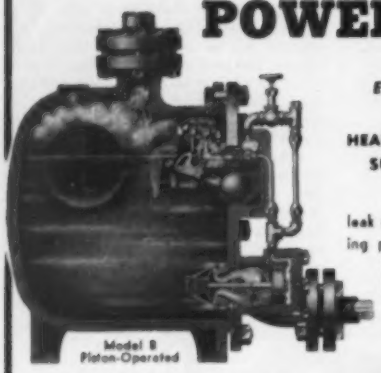
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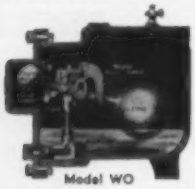
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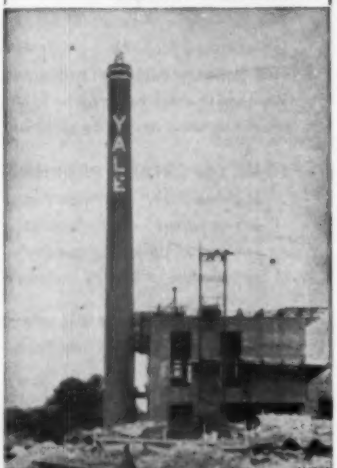

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operates by regulating the secondary air dampers to each burner from an impulse transmitted by the master steam pressure recorder controller. The fuel-air ratio recorder controller regulates the butterfly valve in the blast furnace gas line to each burner to maintain desired fuel-air ratio.

The furnace draft is maintained by regulating the inlet dampers of the I.D. fans. The inlet vanes of the F.D. fans are controlled to maintain constant forced draft duct pressure.

The boiler feedwater control system adjusts the flow of feedwater in accordance with the steam flow from the boiler and maintains the boiler water level and continuous blowdown as desired, at the same time operating the contactors and potentiometers controlling the chemical feed pumps so they will supply chemicals in the desired proportion to the feedwater and steam flows.

All flows, pressures, steam, air, gas and feedwater temperatures, and all necessary drafts are measured by suitable indicating and recording instruments (see list of equipment). These are centralized on the control panel shown in the background of Fig. 2. This is a totally-enclosed operating panel with double doors in each end, a diamond steel floor plate bottom, ¼-in. steel plate top, supplied with clean, cool air by an air filter unit and fan, and with a fluorescent lighting canopy outside across the front of the panel. The panel is mounted on vibration dampeners.

Special Safety Controls

Of particular interest is the provision of special safety devices and interlocks in the boiler control system. These are as follows:

1.—Manual reset solenoid valve for shutting off oil supply in the event of a forced draft fan failure.

2.—Three way solenoid valves to be actuated from contacts provided in circuit breakers of fan motors and so connected that in event of a failure of one forced draft fan, its respective damper will close, whereas with a failure of two forced draft fans the dampers will remain in control position.

3.—Similar arrangement for induced draft fans, except a failure of I.D. fan shuts off its respective F.D. reducing air flow to the fuel-air-ratio controller which regulates the fuel to maintain desired fuel-air ratio. I.D. fan dampers are always open in control position. Failure of both I.D. fans shuts off everything.

4.—A purge interlock device prevents the lighting off of any fuel for 15 minutes following a boiler outage and/or until the air flow through the boiler has reached a pre-determined flow.

5.—Manual reset type 3-way solenoid valves for blast furnace gas shut off. Signal lights, howlers and other warning devices are all tied into the interlock and safety operating cycle, so absolutely necessary for a steam generator firing multiple, gaseous and liquid fuels.

Another interesting feature installed in connection with this unit is the spiral fire escape, the top of which is shown just to the left of the steel stack in Fig. 21. Since there may be men working at various levels on the steam generating unit, the fire escape has direct entrances through swinging doors at operating levels.

Fire protection equipment is described in detail in the list of equipment.

Station piping layout, design and detailed specifications were carried out by the engineering department of The Youngstown Sheet and Tube Co. in co-operation with the manufacturer of the boiler and principal auxiliaries, the piping contractor and the various manufacturers and suppliers as noted on the list of equipment.

After completion of the unit all of the facilities applicable thereto including the unit was painted and a definite color scheme applied. In several instances special rubber base enamels were used to insure satisfactory protection against alkalis and acids. In so far as practical Company standards were followed.

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[1] The Youngstown Sheet and Tube Co. Modernizes its Power Plant; *Power Plant Engineering*, September 1, 1931, pages 876 to 884.

[2] The Design and Maintenance of ID Fan Installations, by Paul R. Duffey, Special Engineer, The Youngstown Sheet and Tube Co.; *Power Plant Engineering*, July 1944, page 88 to 90 and 134.

[3] Chemical Feed Systems, by Robert T. Sheen; *Power Plant Engineering*, May, 1945.

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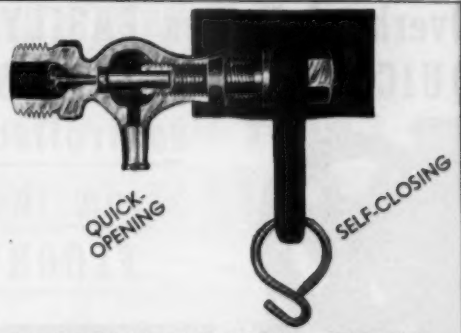

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GAUGE-GLASS PROTECTORS • AIRTITE
BOILER WALL COATING • WATER COLUMNS •
BOILER ALARMS, INSTRUMENTS & CONTROLS

HELPFUL BULLETINS

(Continued from page 36)

structions for selecting and laying out a conveyor installation to suit plant requirements, package breakdown and specifications, and accessories. How-to-do-it information covers capacity and lift factors, location and selection of supports, drive and belt width selection data. Includes layout sheets showing typical conveyor layouts. Barber-Greene Co.

131 Bucket Loaders — Big, heavy-duty loaders of 5 and 8 yd per min capacity and wheel or crawler mounted are described and illustrated in Bulletin H-80-135, 24 pp. Discusses large capacity, economical operating costs of these loaders. Provides general specifications on all types. Explains performance advantages and special construction features and includes photos of many of the loaders at work. Also pictures and describes briefly some of company's other loading and conveying equipment. George Haiss Mfg. Co., Inc., Div., Pettibone Mulliken Corp.

MECHANICAL POWER TRANSMISSION

132 Control Linkage—General Specification CA942, 16 pp, presents control linkage for company's control drive and also contains engineering price data. Explains and illustrates flexible control design drive levers, driven levers, connecting links, bearings and shaft and cable, also rotation over 90 deg. Includes helpful suggestions on selecting linkage and illustrates several typical arrangements. Bailey Meter Co.

133 Mercury Clutches—Bulletin 216, 8 pp, discusses company's mercury clutch, showing how it eliminates many power transmission problems in both electric motor and gasoline engine driven machines, and stressing its 12 outstanding features. Explains how the clutch operates and lists more than 50 applications. Mercury Clutch Div., Automatic Steel Products, Inc.

VENTILATION

134 Fan and Blower Data Book — This 20-pp illustrated catalog gives full engineering information, dimensions, performance characteristics and prices on all types and sizes of fans. Describes several new types of fans with details as to their applications. Includes information on direct drive or belt driven window fans, pressure fans, mancoolers, penthouse units, duct booster fans. Also covers a line of automatic counter balanced shutters. Chelsea Fan & Blower Co., Inc.

135 Heavy Duty Ventilation Filters — Four-pp Form DPF-100.LH introduces company's latest dry panel filter intended to provide an active filtering area of 25 sq ft. Illustrated with photos and performance charts, it elaborates on special features of these filters, telling use and listing sizes available. Also includes installation data, filter selection charts, and descriptions of available media. Dollinger Corp.

OTHER EQUIPMENT

136 What the Neg'ators Can Do—Four-pp Bulletin 310-A describes major forms of the neg'ator—and elastic member possessing either constant force or negative force-deflecting characteristics. In describing the four forms — extension spring, Types A and B motors, and clamps —engineering drawings show how each is constructed and how it works. Photos show how its special properties have been applied. The section on the extension spring explains how the neg'ator can have either zero or negative gradient, also shows "live" and static applications involving constant-force characteristics which permit design simplication. The Type A motor section describes how a constant torque can be obtained with a spring motor. The Type B motor section tells how increased torque can be obtained with same material used in A motors and illustrates long deflections possible. The section on clamps introduces several new clamping concepts. Hunter Spring Co.

137 The Facts on Boiler Return Systems —Sixteen-pp Catalog 55, describing and illustrating boiler return systems, explains what should be considered before buying any type of return system, what should be expected of the equipment involved, and what special advantages company's systems are designed to provide. Discusses standard systems, also pre-heat and heat reclaim systems and two types of deaerating systems, telling applications of each. In addition to full engineering data and specifications, catalog includes photos and descriptions of company's boiler feed pumps, condensation receivers, and boiler water level controls. Fred H. Schaub Engineering Co.

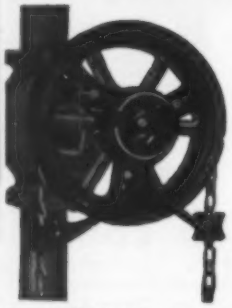
138 Fuel Economizers—Both cast iron tube economizers and steel tube economizers are covered in detail in Catalog 169, 8 pp. Advantages of their diamond-shaped tubes and streamline flow of gas and soot blower steam are discussed; also the tube arrangement which makes outside surface of each tube visible during inspection. Text is illustrated with photos, sectional drawings. Green Fuel Economiser Co., Inc.

139 Double-Walled Tubing — Technical Bulletin 1950, 12 pp, presents tubing designed for conditions where single-walled tube can't withstand simultaneous attack from two types of corrosive media. Describes and illustrates construction of this tubing, illustrating some of its many possible metal combinations. Explains tubing's use in ammonia refrigeration, boilers, steam generators and other applications. Discusses heat transfer properties, high temperature use. Also explains methods of installation with the object of preventing galvanic corrosion. Bridgeport Brass Co.

140 Air Hose—Pocket-size Bulletin 129 explains the design, construction and rubber compounds of an air hose described as a general purpose type with a rayon cord carcass. List available sizes, lengths and colors. Hewitt Rubber Div., Hewitt-Robins, Inc.

141 Temperature Indicators — Pocket Catalog 501, 6 pp, presents briefly company's crayons, pellets and lacquers which indicate temperature by melting at predetermined degrees F. Gives directions for use, lists melting degrees available and prices. Tempil Corp.

Overhead Valves EASILY, QUICKLY AND SAFELY controlled from the FLOOR!



Range of 16 adjustable sizes takes care of all valve makes and types; fits valve wheel diameters from 2 to 30 inches.

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SPROCKET RIM
with Chain Guide

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The BABBITT Rim fits all valves, with either rising or non-rising stems. It is installed quickly by clamping onto the hand wheel of the valve. *Write today for Catalog Bulletin PG, surprisingly low prices, and name of nearest distributor.*

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Fig. 83

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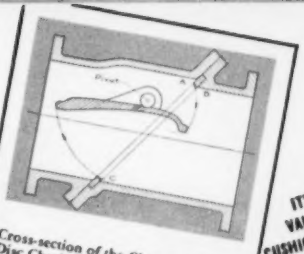
Take just a moment to figure how much the slamming of ordinary check valves is costing you in extra maintenance. You'll find it's *plenty!*

Then switch to Chapman Tilting Disc Check Valves. You'll eliminate the slamming that causes those destructive pipe line stresses. Most of the wear on seats and hinges, too. And head losses will be almost 80% lower than for conventional type check valves.

Those features mean important savings. Yet there are many more. Write today for additional information.



Cross-section of the Chapman Tilting Disc Check Valve illustrating the way that the balanced disc is supported on the pivot, with arrows showing the travel of the disc. A feature of the design is that the disc seat lifts away from the body seat when opening, and drops into contact when closing, with no sliding or wearing of the seats.

The Chapman Valve Mfg. Co. INDIAN ORCHARD, MASSACHUSETTS

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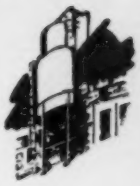

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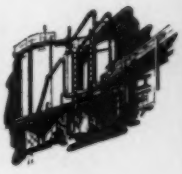

SLUDGE BLANKET HOT LIME SODA. The application of the sludge blanket design to hot lime soda treatment gives you soft water of a low silica content.

HOT ZEOLITE. Subsequent treatment by Permutit Q® yields a final zero-hardness effluent.

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